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Ocean Disposal of Radioactive Wastes: The Obligation of International Cooperation to Protect the Marine Environment*

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The disposal of radioactive waste in the oceans has recently become a public concern in many nations. In the United States, revelations about dumping operations conducted during the period from 1946 to 1970[1] have gained the attention of the media[2] and led to public speculation about the health consequences of old dump sites,[3] especially those relatively close to shore.[4] Dumping opera-

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1. *See Hearings before the Subcomm. on Oceanography of the House Comm. on Merchant Marine and Fisheries*, 96th Cong., 1st & 2d Sess. 341 (1979 & 1980) [hereinafter cited as 1980 *Hearings*] (statement of Roger Mattson).

2. *See, e.g.*, Ackerman, *Bottom of the Sea Getting Hard Look as Site for Disposal of Nuclear Waste*, Boston Globe, May 6, 1980, at 6, col. 1.

3. *See, e.g.*, 11 ENVIR. REP. (BNA) 820 (Oct. 17, 1980).

4. In the United States, at least two such sites are close to shore: the Farallon Islands off

tions recently conducted by several Western European nations have been subject to demonstrations and obstruction.[5] Plans announced by the Japanese government[6] to conduct dumping operations in the North Pacific have caused public protest and generated expressions of concern by several Pacific basin governments.[7]

Continued reliance on nuclear power by a number of nations[8]

San Francisco, and Massachusetts Bay. Dumping at the Farallons site, which accounts for 99% of the total radioactivity dumped into the Pacific by the United States or some 14,500 curies (Ci), is actually a large area extending from 25 to 60 miles from San Francisco with depths from about 900 to 1700 meters (m). Several concentrations of dumped material have been identified within this area. *See* 1980 *Hearings, supra* note 1, at 342 (statement of Roger Mattson); Environmental Protection Agency, Fact Sheet on Ocean Dumping of Radioactive Waste Materials (Nov. 20, 1980) [hereinafter cited as EPA Fact Sheet]. The Massachusetts Bay site is in shallow (92m) waters; it received approximately 2,400 Ci of radioactivity. The most significant Atlantic sites in terms of disposed radioactivity, however, are two sites off the mid-Atlantic States, at 1830-2800m and 1830-3800m depth. These sites received 74,400 and 2,100 Ci respectively. EPA Fact Sheet, at 6.

5. To date, harbors have been blocked by protesting vessels, port operations disrupted by demonstrating crowds, and ships boarded and their equipment damaged. These activities have largely been organized by Greenpeace, an international environmental group. *See* 2 ENVIR. REP. (BNA) 273 (July 9, 1980); Int'l Herald Tribune, June 16, 1980, at 2, col. 7; N.Y. Times, June 11, 1980, § A, at 3, col. 4. Greenpeace has recently applied to become a nongovernmental observer at the consultative meetings of the parties to the Convention on the Prevention of Pollution by Dumping of Wastes and Other Matter, Dec. 29, 1972, 26 U.S.T. 2403, T.I.A.S. 8165, ___ U.N.T.S. ___. [hereinafter cited as London Convention]. To date no action has been taken on its application, apparently due to objections by official delegations. *See* Inter-governmental Maritime Consultative Organization, Fifth Consultative Meeting of Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, Sept. 22-25, 1980, IMCO Doc. LDC V/12, at 4 (1980) [hereinafter cited as LDC-V report].

6. The Japanese government has indicated that initially between 5,000 and 10,000 drums of low level waste will be dumped at a site with a depth of 6,000m located 900 kilometers (km) southeast of Tokyo and about the same distance from the Northern Mariana Islands. 3 INT'L ENVIR. REP. (BNA) 411 (Sept. 10, 1980); N. Y. Times, Aug. 3, 1980, § A, at 13, col. 5. After the Japanese Atomic Energy Commission and the Science and Technology Agency made their announcement, the latter revealed that radioactive wastes had previously been dumped into coastal waters only 40 km from the entrance to Tokyo Bay, between 1955 and 1969. This revelation has aroused the concern of fishermen's groups and area residents. 3 INT'L ENVIR. REP. (BNA) 472-73 (Oct. 8, 1980).

7. These include American Samoa, Guam, Hawaii, districts of Micronesia, the Northern Mariana Islands, New Zealand, and Papua New Guinea. Far Eastern Econ. Rev., Nov. 7, 1980, at 40, 81, 82; N.Y. Times, Oct. 5, 1980, § A, at 13, col. 1; N.Z. Update, Aug. 1980, at 3. A representative of the Northern Marianas has been quoted in the Japanese press as indicating that his government would move to exclude Japanese vessels from its fishing zone if Japan proceeds with its plan. 3 INT'L ENVIR. REP. (BNA) 411 (Sept. 10, 1980).

8. It is beyond the scope of this paper to speculate about the development of nuclear power. Public concern about the safety of nuclear power plants and the environmental effects of uranium mining and milling, fuel reprocessing, and nuclear waste disposal, as well as the hazards of the proliferation of nuclear weapons as a result of the spread of nuclear technology, has led to greatly reduced estimates of the development of nuclear power. All

will generate considerable amounts of radioactive waste of widely varying forms and levels of radioactivity. Some of these nations, especially those with constraints on land disposal of such wastes, will probably tend to rely in part on ocean disposal—at least for low level wastes. Though the public appears generally to disapprove of such disposal, the consequences of marine disposal of radioactive wastes are better understood than the consequences of marine disposal of many other types of waste substances.[9] While records are not complete, considerable information is available on the radioactive wastes which have been dumped offshore.[10] It is also possible to locate existing dumpsites and to monitor them to a certain extent.[11]

Ocean disposal of radioactive wastes has been subject to greater international concern and control than for any other wastes except oil discharged from vessels.[12] Although the international instru-

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estimates given here for the volume of wastes generated by nuclear power operations will be formulated in terms of a realistic range of values based on current projections. *See* text at notes 105-07 *infra*. Similarly, the discussion herein is generally independent from the issue of which nuclear fuel cycles will be chosen for power production and in what proportion. The most important issue in this regard is whether and to what extent the developed nations, and perhaps selected less developed nations, will reprocess the spent fuel generated from conventional nuclear power reactors. *See* text at notes 96-104 *infra*. Aside from the political issues involved, reprocessing would affect waste management since the characteristics and volume of process waste from the nuclear fuel cycle would differ significantly according to whether spent fuel or reprocessing wastes are disposed. *See* text at notes 96-107 *infra*. The latter wastes are what has traditionally been considered "high level waste", both for overall waste management purposes and for ocean dumping. *See* ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, NUCLEAR ENERGY AGENCY, OBJECTIVES, CONCEPTS AND STRATEGIES FOR THE MANAGEMENT OF RADIOACTIVE WASTE ARISING FROM NUCLEAR POWER PROGRAMS 29 (1977) [hereinafter cited as NEA Study]. In terms of potential ocean disposal of such wastes, both spent fuel and high level waste from reprocessing present similar issues, since there is little significant difference between them in levels of radioactivity or rate of radiological decay, even though nearly all the plutonium and residual uranium would be removed from high level reprocessing waste. *See* Krugman & von Hippel, *Radioactive Waste: The Problem of Plutonium,* 210 SCI. 319 (1980).

9. *See generally* Preston, *The Radiological Consequences of Releases from Nuclear Facilities to the Aquatic Environment* [hereinafter cited as Preston], in IMPACTS OF NUCLEAR RELEASES INTO THE AQUATIC ENVIRONMENT 3 (Int'l Atom. Energy Agency Proc. Ser., Otaniemi Symp., 1975) IAEA Doc. IAEA-SM-198/58 [hereinafter cited as Otaniemi Symposium]. The dumping of radioactive materials associated with applications of nuclear technology has historically been more strictly regulated than the dumping of other wastes. *See* Böhme, *The Use of the Seabed as a Dumping Site,* in FROM THE LAW OF THE SEA TOWARDS AN OCEAN SPACE REGIME 93, 105 (1972).

10. *See* EPA Fact Sheet, *supra* note 4, at 1-8.

11. *See 1980 Hearings, supra* note 1, at 350-52 (testimony of Roger Mattson); *id.* at 378-431 (testimony of Robert Dyer); EPA Fact Sheet, *supra* note 4.

12. *See* Böhme, *supra* note 9, at 117; Moore, *Legal Aspects of Marine Pollution Control,*

ments that cover radioactive waste dumping apply to other wastes as well,[13] only radioactive waste dumping operations have been organized and conducted on a multilateral basis.[14] Radioactive wastes are the only dumped wastes subject to standards and recommended criteria developed by an international organization.[15] They are also the only dumped substances for which international agreements require prior notification and consultation.[16]

Because radioactive wastes already occupy a unique position in international regulation of waste disposal, the control of their disposal provides an excellent example of international organization for protection of the marine environment. This article will examine the nature of ocean disposal of such wastes, the applicable substantive legal standards, and the history of international cooperation in this activity. It will argue that ocean disposal of radioactive wastes is subject to the requirement that it be conducted only in accordance with international standards and procedures formulated as a result of *bona fide* consultation among states. It will also suggest that, in developing the standards and procedures by which to evaluate such activities, special attention must be given to considerations of international equity.

I. OCEAN DISPOSAL OF RADIOACTIVE WASTES

Radioactive wastes—substances with significant levels of radioactivity which are released or otherwise disposed of in connection with nuclear power or weapons production or other human activities involving radioactive substances[17]—enter the marine environ-

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in MARINE POLLUTION 589, 601 (R. Johnston ed. 1976).

13. *See* notes 73-74 *infra* & accompanying text.

14. *See* notes 66-72 *infra* & accompanying text.

15. *See* note 75 *infra* & accompanying text.

16. *See* notes 75-78, 417-19 *infra* & accompanying text. *See also* Schwebel, Second Report on the Law of the Non-Navigational Uses of International Watercourses, U.N. Doc. A/CN.4/332 (Apr. 24 1980).

17. Many substances, including substances disposed of at sea, contain some level of radioactivity. Some of this is primordial (present in the earth as a result of natural processes) or cosmogenic (resulting from radiation received from outer space); this level of naturally-occurring radioactivity is called the natural background. Radioactivity is also generated by civilian nuclear technology—including nuclear power production, wastes from nuclear medicine and laboratory research, as well as isotopes deliberately discharged into the environment for research purposes. *See* text at notes 17-24, 28-33, 44-51, 63-67, *infra*. Much more significant to date, in quantitative terms, have been releases of radioactivity from nuclear explosives testing in the atmosphere.

The fact that many substances with naturally high or with artificially enhanced levels of ment in many ways. The "front end" of the nuclear fuel cycle, leading to the fabrication of fuel for reactors out of naturally occurring sources of uranium, generates mining and milling tailings and sludges,[18] components of which may reach the ocean through runoff from land. Nuclear power plant operations result in discharges of liquid effluent into rivers or coastal waters. It is "back end" activities, however, especially reprocessing and waste disposal, which present the chief causes of concern.[19] Reprocessing plants may discharge contaminated wastes into coastal waters or rivers. Spent fuel from reactors or high level wastes from reprocessing may be discarded at ocean locations or otherwise transported to the ocean by runoff of releases from continental disposal sites.[20] Nuclear reactors used to power vessels produce small discharges of induced radioactivity in cooling water, as well as certain operational releases.[21] Each stage of nuclear power production creates large volumes of low level radioactive waste in the form of

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radioactivity may sometimes be disposed of at sea creates a problem of definition about what actions should be viewed as constituting deliberate ocean disposal of radioactive waste. Work is now proceeding under the auspices of the International Atomic Energy Agency (IAEA) to determine what substances should not be considered as radioactive waste when dumped at sea and which other substances should be considered to have *de minimis* amounts of radioactivity so that they could be dumped under more lenient provisions than for other radioactive wastes. *See* notes 46-49 *infra* & accompanying text. National authorities may also determine for purposes of the London Convention what constitutes a radioactive waste subject to regulation. *See* International Atomic Energy Agency, Information Circular, Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, the Definition required by Annex I, paragraph 6 to the Convention, and the Recommendations Required by Annex II, section D, INFCIRC/205/Add.1/Rev.1 (1978), Annex at ¶ 2.3.14 *reprinted in* 18 INT'L LEGAL MATERIALS 826 (1979) [hereinafter cited as IAEA Definition and Recommendations]; note 48 *infra*.

18. The gravity of the problem of containment of the radioactivity present in these substances has only recently been recognized. *See, e.g.*, The Uranium Mill Tailings Radiation Control Act of 1978, Pub. L. No. 95-604, 92 Stat. 3021 (1978).

19. *See generally* G. ROCHLIN, PLUTONIUM, POWER, AND POLITICS 67-100 (1979).

20. The chief environmental concern with disposal of high level radioactive wastes in continental geological formations, as proposed by the United States and other governments, *see* note 117, *infra*, is breach of primary containment followed by transport by groundwater. *See* 1 U.S. DEPARTMENT OF ENERGY, FINAL ENVIRONMENTAL IMPACT STATEMENT, MANAGEMENT OF COMMERCIALLY GENERATED RADIOACTIVE WASTE 5.1-5.14 (1980) [hereinafter cited as DOE GENERIC EIS]. Because of the nature of high level waste, see text at notes 82-108 *infra*, its release from a repository within national territory would inevitably affect the environment of other states and the global commons. *See* NEA STUDY, *supra* note 8, at 61.

21. *See* NATIONAL RESEARCH COUNCIL COMMITTEE ON OCEANOGRAPHY, NATIONAL ACADEMY OF SCIENCES, RADIOACTIVITY IN THE MARINE ENVIRONMENT 24 (1971) *reprinted in Radiological Contamination of the Oceans: Hearings Before the Subcomm. on Energy and the Environment of the House Comm. on Interior and Insular Affairs* 288, 94th Cong., 2d Sess. (1976) [hereinafter cited as NAS STUDY].

contaminated clothing, cleaning agents, and equipment.[22] Research and the practice of nuclear medicine generate these and other types of low level wastes. Much of such low level waste is currently dumped into the ocean.[23] Finally, the decommissioning of nuclear facilities (including vessels) presents the problem of large contaminated structures which could be disposed of at sea.[24]

This section will consider the deliberate use of the oceans and seabed as a disposal location for materials with a significant amount of radioactivity resulting from civilian nuclear power production and other civilian applications of nuclear technology. The primary activities of concern are discharges of effluents from nuclear facilities and disposal of retained wastes of various levels of radioactivity resulting from nuclear power production. Low level wastes from medicine and research will be considered along with similar wastes arising from nuclear power operations. Although military activities result in equivalent types of waste, they will not be considered except to the extent that their disposal presents equivalent technical and legal problems.[25] Effluents resulting from nuclear vessel operations,[26] which are primarily military at present,

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22. *See* notes 44-48 *infra*.

23. *See* notes 67-72 *infra* & accompanying text.

24. In 1959 the United States disposed of the decommissioned reactor of a nuclear submarine, the *Seawolf*, by dumping it at sea. Carter, *Navy Considers Scuttling Old Nuclear Subs*, 209 SCI. 1495, 1496 (1980). The U.S. Navy is apparently once again considering disposing of nuclear submarine reactors by dumping or scuttling. *Id.*

25. The ability of foreign nationals or governments to challenge actions in various maritime zones subject to national jurisdiction—*e.g.*, inland waters, territorial sea, exclusive economic or other resource zone, and the high seas and seabed beyond national jurisdiction—may depend on whether such activities are conducted by a government, authorized by a government, or undertaken with the knowledge of a government. For example, a government may have the right to establish environmental policies in certain areas such as the territorial sea, but citizens exercising their rights under such policies might still be liable to another state or third party nationals of that state for damages to their interests. Similarly, their government might be liable: some existing international law on international environmental obligations is formulated in terms of the obligation of a state to restrict activities within its territory that cause damages within the territory of another state. *See, e.g.*, Trail Smelter Case (United States v. Canada) 3 R. Int'l Arb. Awards 1905 (1938 & 1941). *See generally* Handl, *State Liability for Accidental Transnational Environmental Damage by Private Persons*, 74 AM. J. INT'L L. 525 (1980). Nevertheless, the actions of governments can be protected by the act of state doctrine or by sovereign immunity. Furthermore, under existing international agreements, government actions are exempted from procedural and even substantive requirements. Public vessels are exempted from international regulation of waste dumping at sea under the London Convention, *supra* note 5, art. VII(4).

26. There is a substantial body of literature on the liabilities of the operators of nuclear vessels. *See, e.g.*, J. BALLENEGGER, LA POLLUTION EN DROIT INTERNATIONAL 160-76 (Travaux de droit, d'économie, de sociologie et de sciences politiques no. 105, 1975). Little has been

will not be considered, nor will accidental releases of radioactive material resulting from maritime accidents except as they relate to ocean disposal operations.[27]

A. *Effluent Discharges*

Radioactive effluents are discharged from nuclear power plants and their spent fuel storage pools as a result of irradiation of impurities in cooling water, corrosion of exposed cooling system pipes, leaks and spills of contaminated fluids, and occasional venting of radioactive gases to release pressure in the reactor vessel.[28] Cooling system discharges enter rivers or coastal waters but the resulting dose to man[29] and living marine resources is considered insignificant.[30] More significant are discharges from reprocessing

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written concerning the obligations of such vessels with respect to protection of the marine environment as such. As vessels operating on the high seas exercising the traditional freedom of navigation, nuclear vessels would be required to refrain from such pollution as would adversely affect the reasonable use of the high seas by the nationals of other states. Geneva Convention on the High Seas, Apr. 29, 1958, art. 2, 13 U.S.T. 2312, T.I.A.S. No. 5200, 450 U.N.T.S. 82, (entered into force Sept. 30, 1962) [hereinafter cited as High Seas Convention]. When in maritime zones subject to some form of national jurisdiction, such vessels may be subject to special documentation and notification requirements. *See* Third United Nations Conference on the Law of the Sea, Draft Convention on the Law of the Sea (Informal Text), art. 23, U.N. Doc. A/CONF.62/WP.10/Rev.3/Add.1 (1980) (obligation of foreign nuclear powered ships or ships carrying nuclear cargoes to carry documents and observe special precautionary measures established by international agreement while in innocent passage in the territorial sea) [hereinafter cited as Draft LOS Convention].

27. Ships carrying radioactive cargoes, in addition to whatever obligations to which they may be subject by general law, are also subject to the provisions of the International Convention for the Safety of Life at Sea, (SOLAS), July 17, 1960, 16 U.S.T. 185, T.I.A.S. No. 5780, 536 U.N.T.S. 27, *as amended*, ___ U.S.T. ___, T.I.A.S. No. 9700, *done* Nov. 1, 1974, (entered into force May 25, 1980). Radioactive substances are included as Class VII dangerous goods in this convention. As such, they are subject to regulatory provisions under codes of safe operation promulgated by the International Maritime Consultative Organization (IMCO). In certain cases, the liability of operators of such vessels is transferred to that of the operators of the facilities to or from which the nuclear material is bound, under the 1971 Brussels Convention Relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material, Dec. 17, 1971, *reprinted in* 11 INT'L LEGAL MATERIALS 277 (1972).

28. *See generally* U.N. SCIENTIFIC COMMITTEE ON THE EFFECTS OF ATOMIC RADIATION, SOURCES AND EFFECTS OF IONIZING RADIATION 172-99 (1977) [hereinafter cited as UNSCEAR REPORT].

29. For estimated doses, see *id.*, at 197-200.

30. For a characterization of the significance of dose commitments to man and marine organisms, see Preston, in Otaniemi Symposium, *supra* note 9 at 3, 10-13. For informaton tending to show that the exceptionally large concentration of military reactors at Hanford, Washington has not had an effect on the rich marine resources of the Columbia River or the river's plume at sea, see Osterberg, *Radiological Impacts of Releases from Nuclear Facilities into Aquatic Environments—USA Views*, in Otaniemi Symposium, *supra* note 9, at 25,

facilities.[31] Reprocessing of spent nuclear fuel is a chemical process[32] which produces contaminated wastes, some of which are discharged for economical operation.[33] Since some of the radioactive wastes generated by reprocessing result from direct contact with spent nuclear fuel, they contain significant amounts of transuranics[34] as well as a wide range of other radionuclides. Existing commercial reprocessing plants such as those at Seascale, U.K. ("Windscale"), and Cap de la Hague and Marcoule, France discharge a sufficient amount of radionuclides to justify concern about the health consequences, especially for exposed groups in the population. In the case of Windscale, considerable information is available concerning the distribution of discharged radionuclides and their return to exposed human populations.[35] Apparently, information on the actual absorption of such substances by these groups is not readily available.[36]

26-28. In the United States, civilian nuclear plant operators are required to keep such discharges "as low as is reasonably achievable." 10 C.F.R. § 50.34a (1980). *See also* 10 C.F.R. § 50.36a & app. I (1980). For an analysis concluding that the releases from operating plants in 1973 were generally within the Appendix I objectives, see Kastner & Bland, *Assessment of Doses in the Environment for Liquid Releases from Nuclear Power Reactors*, in Otaniemi Symposium, *supra* note 9, at 405.

31. *See* Hetherington, Jefferies, Mitchell, Pentreath & Woodhead, *Environmental and Public Health Consequences of the Controlled Disposal of Transuranic Elements to the Marine Environment* [hereinafter cited as Hetherington *et al.*], in TRANSURANIUM NUCLIDES IN THE ENVIRONMENT 139, (Int'l Atomic Energy Agency Proc. Ser., San Francisco Symp., 1976) IAEA Doc. IAEA-SM-199/11, [hereinafter cited as San Francisco Symposium]; Preston, in Otaniemi Symposium, *supra* note 9, at 3, 11.

32. The universally employed chemical process is the "Purex" process but a number of mechanical methods are available to perform the chemical reactions. *See generally* Bebbington, *The Reprocessing of Nuclear Fuels*, SCI. AM., Dec. 1976, at 30.

33. Hetherington *et al.*, in San Francisco Symposium, *supra* note 31, at 139.

34. *See* UNSCEAR REPORT, *supra* note 28, at 200-02. The transuranics are elements with a higher atomic number than uranium, *i.e.* 92. M. WILLRICH & R. LESTER, RADIOACTIVE WASTE: MANAGEMENT AND REGULATION 125-26 (1977). They result from processes associated with capture of a neutron by uranium or another member of the actinide series of elements during a fission reaction. *See* NEA STUDY, *supra* note 10, at 28. The transuranic elements are generally alpha-particle emitters with a long half-life. *Id.* The most important examples here are the isotopes of plutonium and americium. *See* Hetherington *et al.*, in San Francisco Symposium, *supra* note 31, at 140-41.

35. *See, e.g.*, Hetherington *et al.*, in San Francisco Symposium, *supra* note 31; Preston & Mitchell, *Evaluation of Public Radiation Exposure from the Controlled Marine Disposal of Radioactive Waste (With Special Reference to the United Kingdom)* [hereinafter cited as Preston & Mitchell], in RADIOACTIVE CONTAMINATION OF THE MARINE ENVIRONMENT 575, IAEA Doc. IAEA-SM-158/36 (Int'l Atom. Energy Agency Proc. Ser., Seattle Symp., 1973) [hereinafter cited as Seattle Symposium].

36. Hetherington *et al.*, in San Francisco Symposium, *supra* note 31, at 154.

Control of reprocessing discharges in the United Kingdom[37] and elsewhere in the European community is based on the recommendations of an international scientific body, the International Commission on Radiological Protection (ICRP).[38] The ICRP has established dose limitations for individuals for exposure from all sources, based on health considerations.[39] Under the ICRP recommendations, no practice leading to radiological exposure should be adopted unless it produces a net benefit; exposures should be "kept as low as reasonably achievable, economic and social factors being taken into account"; and the level of exposure to individuals at present or in the future should not exceed the limits established for the circumstance in question.[40] To determine individual exposure limits a "critical pathway" analysis is undertaken to estimate the transmission of the most significant radionuclides (from which total exposure is calculated by proportion to the monitored nuclides) to the most exposed group in the population through the most important pathways.[41] It is generally thought that if the ex-

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37. Radioactive Substances Act 1960, 8 & 9 Eliz. 2 c.34, § 6. *Accord,* ROYAL COMMISSION ON ENVIRONMENTAL POLLUTION, SIXTH REPORT, NUCLEAR POWER AND THE ENVIRONMENT 90 (1976) [hereinafter cited as ROYAL COMMISSION REPORT].

38. The ICRP and its predecessor organizations have existed since 1928; it is composed of independent experts from various countries. The ICRP provides technical guidance in the entire field of radiation protection, including establishing guidelines for human exposure. 16 HALSBURY'S LAWS OF ENGLAND ¶ 237,242 (4th ed. 1976); ROYAL COMMISSION REPORT, *supra* note 37, at 87.

39. *Recommendations of the International Commission on Radiological Protection,* in ANNALS ICRP ¶ 1 (ICRP Pub. No. 26, 1977) [hereinafter cited as *ICRP Recommendations*]. The ICRP previously also issued dose limits for entire populations based on the principle of genetic protection. It has decided in its latest recommendations that since, *inter alia,* these limits were unlikely to be reached it was undesirable to continue to issue them. Instead of such limits, the ICRP has proposed the justification of all proposed exposures by their benefits. *Id.,* at ¶ 12. This is the same procedure that is followed for anticipated doses to individuals. *See* text at note 40 *infra.* For the disposal of high level radioactive waste, especially in the oceans, however, it is possible that long-term effects on populations could become an independently limiting factor. *Cf.* Preston, in Otaniemi Symposium, *supra* note 15, at 3, 5 (significance of population doses of long-lived radionuclides).

40. *ICRP Recommendations, supra* note 39, at ¶ 12-13.

41. *See* Preston & Mitchell, in Seattle Symposium, *supra* note 35, at 576-82. In the case of discharges from Windscale, the critical group is a coastal population which either consumes a certain seaweed product (laverbread, a food stuff comprised of seaweed of the genus Porphyra, *id.* at 582) or comes into contact with contaminated sediments while fishing. *Id.,* at 582-87. Several factors complicate this situation. First, seaweed collected from the area near Windscale were mixed with that from other areas during processing. *Id.,* at 583. Second, collection of the seaweed from the area is reported to have ceased, but could resume. *See* Hetherington *et al.,* in San Francisco Symposium, *supra* note 31, at 145.

British figures based on this form of analysis show that the exposure of the critical popuposure to humans does not exceed recommended limits then marine life will not be affected, at least on the population level.[42] However, the effects of effluent discharges from reprocessing are not fully known. While there does not appear as yet to be any evidence that significant concentrations in the coastal waters of neighboring states or in deep ocean areas have resulted from reprocessing operations, it would appear possible that such effects could occur as a result of the transport of discharged reprocessing wastes.[43]

B. *Low Level Waste Dumping*

An enormous volume of low level waste is generated by nuclear power and other applications of nuclear technology.[44] In the United States alone, civilian nuclear activities may result in over

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lation has occasionally reached ten percent, and sometimes forty percent, of ICRP limits. There does not appear to be a general policy on what percentage of total ICRP limits is acceptable for exposures from this source. *See generally id.*; Webb, *The Interaction Between Radiological Assessments and Research Requirements Related to Waste Disposal in the Deep Sea*, in ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, NUCLEAR ENERGY AGENCY PROCEEDINGS OF THE THIRD NEA SEMINAR ON MARINE RADIOECOLOGY 13-14 (1980) [hereinafter cited as NEA Tokyo Seminar].

42. Woodhead, *Levels of Radioactivity in the Marine Environment and Dose Commitment to Marine Organisms*, in Seattle Symposium, *supra* note 35, at 499, 499, 521-522.

43. The effects of discharges from Windscale is a good example of the consequences of widespread reprocessing, if radioactive releases of substantial magnitude are permitted. The primary problem in determining national regulatory policy for such discharges is the health of exposed groups in the population. Another consideration is the transport of discharged substances beyond the coastal waters of the state in which they occur. Discharges from Windscale and the French reprocessing plant at Cap de la Hague have been detected in several coastal areas around the North Sea and elsewhere, especially in Denmark and Norway; they also are transported into the Baltic Sea and into the Arctic. Kautsky, *The North Sea Region Taken as an Example for the Behavior of Artificial Radioisotopes in Nearshore Sea Areas*, in NEA Tokyo Seminar, *supra* note 41, at 283.

44. Low level waste will be taken to include all solid substances or substances incorporated into a solid form which are considered radioactive wastes, see notes 46-47, *infra*, but which are not high-level waste from nuclear power generation or weapons production, i.e., are not spent nuclear fuel or chemical contact wastes from spent fuel reprocessing, see text at notes 82-95, *infra*. There is considerable disagreement over the classification of radioactive waste for various purposes—occupational exposure, inherent radioactivity, or method of disposal including sea dumping. *See, e.g.*, text at note 79 *infra*. From the waste disposal perspective, the most important consideration in classifying waste is whether it contains significant amounts of long-lived transuranic nuclides (TRU). *See generally* M. WILLRICH & R. LESTER, *supra* note 34, at 6, 16-17. This TRU waste includes the cladding of spent nuclear fuel and various equipment used in connection with nuclear power operations, especially reprocessing. *See id.* at 12. TRU waste, like low level waste, is produced in large volumes; commercial power operations in the U.S. alone will probably result in some 50 million cubic feet by the year 2000. *See id.* at 16.

275 million cubic feet of low level waste by the year 2000.[45] Estimating the total amounts of radioactivity included in low level wastes becomes difficult because it is not immediately apparent which radioactive substances constitute the wastes from human activities.[46] Furthermore, no clear threshold level of radioactivity exists for the purpose of determining when to treat waste as low level radioactive waste.[47] Much waste associated with nuclear activities has a level of activity detectable above background levels but so low that it could be considered a *de minimis* amount that should not be subject to the full range of controls applicable to other forms of low level waste.[48] The definitional problem is compounded

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45. *Ocean Dumping and Pollution: Hearings before the Subcomm. on Oceanography and the Subcomm. on Fisheries and Wildlife Conservation and the Environment of the House Comm. on Merchant Marine and Fisheries*, 95th Cong., 1st & 2d Sess. 196 (1977 & 1978) (statement of John Deutch).

46. In the case of sea dumping of radioactive substances, this question has come up because under the chief existing international instrument regulating dumping of radioactive wastes at sea there is no requirement that there be significant quantities of radioactivity in a material to be dumped before a special permit is required for the operation. London Convention, *supra* note 5, art. IV(1)(b) & Annex II (D). Furthermore, once a substance has been characterized as radioactive there is no provision for general permits to be issued. *See id.* However, parties to the London Convention may define a *de minimis* level of radioactivity and in the interim national authorities should have some flexibility of interpretation in applying the IAEA recommendations. IAEA Definitions and Recommendations, *supra* note 17, at 2.3.14. An advisory group to the IAEA has recently proposed a qualitative criterion for determining whether substances should be considered radioactive under the Convention. The criterion is intended to exempt

> most materials which have not been in contact with, associated with, or intended for use in any anthropogenic nuclear process, excepting contamination by the global dissemination of debris from nuclear weapons testing or which have not been exposed to man-made nuclear radiations in such a way as to lead to the activation of stable elements in the original material.

Considerations concerning "de minimis" quantities of radioactive waste suitable for dumping at sea under a general permit, IAEA Doc. IAEA TECDOC-244, at 10 (1981).

47. The IAEA advisory group on this matter has also proposed a quantitative definition of *de minimis* amount for sea dumping based on a modelled resulting dose to human populations. *Id.* ch. 4. It is unclear how an amount calculated in this fashion would relate to the customary value given for *de minimis* levels of inherent radioactivity—*i.e.* 10^{-3} curies per ton (Ci/T). Stein, *L'Application aux pollutions d'origine radioactive des conventions internationales protectrices de la mer*, in DROIT NUCLÉAIRE ET DROIT OCEANIQUE 116, 126 (1975) [hereinafter cited as DROIT NUCLÉAIRE/OCÉANIQUE-COLLOQUE].

48. The U.S. Nuclear Regulatory Commission (NRC) has recently proposed to deregulate certain radioactive wastes containing *de minimis* amounts of radioactivity. The U.S. Nuclear Regulatory Commission has recently proposed, for example, to deregulate certain radioactively-contaminated scrap metals, 45 Fed. Reg. 70,874 (1980)(proposed rule), and has deregulated certain biomedical wastes, 46 Fed. Reg. 16,230 (1981)(final rule). The NRC proposal to cease treating certain wastes as radioactive aroused some public opposition. *See, e.g.*, Letter from J. Johnsrud to the Editor, *reprinted in* N.Y. Times Dec. 20, 1980, § A, at

by disagreement within the scientific community as to the biological significance of extremely low doses of radioactivity.[49] It is similarly difficult to estimate the total quantities of such wastes by volume or weight because of the methods of packaging low level waste for disposal. For sea disposal, low level wastes are usually incorporated into concrete and packaged in steel drums.[50] Some five to twenty-five thousand such containers will probably be dumped annually over the next several years.[51]

The United States disposed of low level waste by dumping at sea during the period 1946-1970, although no permits were issued to new firms after 1960.[52] During this period dumping operations were subject to regulation by the Atomic Energy Commission (AEC),[53] following the pattern set by other countries[54] in the period before international controls on sea dumping were instituted. Approximately 94,630 curies (Ci) of radioactivity were dumped, in about 89,750 containers.[55] Dumpsites were located at a variety of depths,[56] some on the continental shelf and others in deeper areas. Sea dumping declined in importance after 1962 and operations were terminated in 1970[57] upon adoption of a stricter policy by the AEC.[58] The usual interpretation[59] is that concerns about dumping,

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24, col. 3.

49. The scientific question is whether cancer rates determined for higher doses should be extrapolated to lower doses linearly, or whether there is a threshold under which a greatly reduced rate of cancer would occur. *See generally* Land, *Estimating Cancer Risks from Low Doses of Ionizing Radiation*, 209 SCI. 1197 (1980). The National Academy of Sciences has, in a controversial report on this subject, roughly split the difference between the two approaches (which would still put the projected cancer rate for low doses below the linear extrapolation). Reinhold, *Science Unit Revises Study on Radiation's Cancer Risk*, N.Y. Times, July 30, 1980, at § A, at 12, col. 1.

50. *See* NAS STUDY, *supra* note 21, at 36; ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, NUCLEAR ENERGY AGENCY, GUIDELINES FOR SEADUMPING PACKAGES OF RADIOACTIVE WASTE 16 (rev. ed., 1979).

51. INTERNATIONAL ATOMIC ENERGY AGENCY BOARD OF GOVERNORS, THE AGENCY'S ROLE IN CONNECTION WITH THE CONVENTION ON THE PREVENTION OF MARINE POLLUTION BY DUMPING OF WASTES AND OTHER MATTER, IAEA Doc. GOV/1820, Annex at 8 (1977).

52. 1980 *Hearings*, *supra* note 1, at 341 (statement of Roger Mattson).

53. *Id.*

54. *See* Böhme, *supra* note 9, at 105-06.

55. EPA Factsheet, *supra* note 4, at 3.

56. *See id.* at 4-7.

57. EPA Factsheet, *supra* note 4, at 3.

58. The AEC regulations required a showing by the applicant that the proposed dumping would offer less harm to man or the environment than other practical alternatives. 10 C.F.R. § 20.302 (1980).

59. *See, e.g.*, 1980 *Hearings*, *supra* note 1, at 341-43 (statement of Roger Mattson).

combined with lessened economic attractiveness of the method due to the availability of sites for shallow burial on land, put an end to the practice. With passage of the Marine Protection, Research and Sanctuaries Act[60] in 1972, the Environmental Protection Agency (EPA) assumed jurisdiction over the activity.[61] Although ocean dumping may be conducted under the terms of EPA regulations,[62] none has occurred. The EPA is now, however, considering allowing the practice to resume under new regulations.[63]

Several other industrialized nations have also practiced sea dumping of low level waste. Japan permitted dumping at near-shore sites from 1955 to 1969.[64] Prior to 1967 individual European countries, primarily the United Kingdom, conducted dumping operations; it is reported that the United Kingdom dumped over 49,000 Ci in deep waters of the North Atlantic.[65] In 1967, the Nuclear Energy Agency (NEA)[66] of the Organization for Economic Cooperation and Development (OECD) assumed organizational responsibility for European operations.[67] Dumping operations were then organized and conducted by the NEA in nearly each succeeding year.[68] Since 1971, however, only Belgium, the Netherlands, Switzerland, and the United Kingdom have dumped wastes at sea under NEA auspices.[69] All NEA-supervised dumping has occurred at depths of over 11,000 feet in the North Atlantic, although the dump site was redefined in 1977.[70] The yearly amounts of waste dumped have grown from 7,850 Ci in 1967 to 84,500 Ci in 1979;[71] total dumping for the period 1967-1979 exceeds one-half million curies.[72]

After Western European radioactive waste dumping operations

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60. 33 U.S.C. §§ 1401-1421 (1976).

61. *Id.* § 1412(a).

62. *See* 40 C.F.R. §§ 227.1-227.13 (1980).

63. 1980 *Hearings, supra* note 1, at 352-53 (statement of Roger Mattson).

64. 3 INT'L ENVIR. REP. (BNA) 472 (Oct. 8, 1980).

65. NAS STUDY, *supra* note 21, at 38. *See also* Dyer, *Sea Disposal of Nuclear Waste: A Brief History* 5 (unpublished manuscript, copy on file with the author).

66. Then the European Nuclear Energy Agency (ENEA). The "E" was deleted upon accession by Japan. 10 NUCLEAR L. BULL. 25 (1972).

67. *See* ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, EUROPEAN NUCLEAR ENERGY AGENCY, RADIOACTIVE WASTE DISPOSAL OPERATION INTO THE ATLANTIC 1967 5 (1968).

68. *See* Dyer, *supra* note 65, at 6, Table II.

69. *Id.* at 6.

70. *Id.* Table II.

71. *Id.*

72. *Id.* at 7.

came under the supervision of the NEA, regional legal arrangements were also made to control waste dumping.[73] Global control of dumping became a possibility with adoption in 1972 of the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, which entered into force in 1975.[74] An international framework for notification and periodic consultation under general standards arose as a result of the various conventions. As far as operational matters are concerned, however, cooperation within the NEA has been most significant[75] for those countries practicing dumping and those others which have thus far shown the greatest concern with it. The NEA has performed such basic operational functions as designating the dump site, arranging and supervising transportation and dumping, and arranging for financial security.[76] It has also issued guidelines on the design of packaging for dumped wastes[77] and operational procedures.[78]

Despite existing knowledge and controls, the public has reacted negatively to low level waste dumping because of the unsettling image of rusting drums on the bottom of the sea and the sloppy practices of government agencies in the past in planning, executing, monitoring, and recording dumping.[79] The consensus of the scientific community appears to be that past disposal practices in the United States do not present a health threat and a marine di-

73. In 1972, twelve European Countries signed the Oslo Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft, which came into force in 1974. Under this convention, the parties agreed *inter alia* not to permit dumping of certain (Annex II) substances into the Convention waters without a special permit issued by the appropriate national authority. Although Annex II does not expressly include low level radioactive wastes, it is thought that these are covered. The Commission established by the Convention is to be notified of permits issued for such dumping; it may provide its opinion on dumping activities. Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft, *reprinted in* 11 INT'L LEGAL MATERIALS 262 (1972) [hereinafter cited as Oslo Convention].

74. London Convention, *supra* note 5.

75. *See generally* Reyners, *La Pratique des évacuations en mer des déchets radioactifs et nécessité d'une réglementation internationale*, in DROIT NUCLÉAIRE/OCÉANIQUE-COLLOQUE, *supra* note 47, at 95, 107-12.

76. *See id.* at 108-112.

77. ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, NUCLEAR ENERGY AGENCY, GUIDELINES FOR SEA DUMPING PACKAGES OF RADIOACTIVE WASTE (REV. ED., 1979).

78. ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, NUCLEAR ENERGY AGENCY, RECOMMENDED OPERATIONAL PROCEDURES FOR SEA DUMPING OF RADIOACTIVE WASTE (1979).

79. *See generally* 1980 *Hearings*, *supra* note 1 at 265-69 (testimony of Congressman Glen M. Anderson).

saster is unlikely.[80] European nations have permitted a much larger amount of ocean disposal of low level wastes. The magnitude of these operations,[81] and the possibility of future dumping by nations such as Japan, the United States, and other nations with substantial nuclear power or research programs indicate the need to regulate dumping so that sound radiological protection principles are followed. To do so will require detailed scientific study to monitor existing sites, formulate standards, and assess sites for their suitability.

C. *High Level Waste Disposal*

Nuclear fission of uranium or other actinide fuel generates lighter elements known as fission products.[82] The fission products created by this splitting of heavier atoms are often unstable and go through a complex chain of radioactive decay. It is this process of decay which generates the considerable beta and gamma radiation,[83] as well as most of the heat,[84] in the wastes arising from nuclear power production. The period in which fission product decay dominates the hazard of the waste lasts about 700 years.[85] Spent fuel consists of fission products and other elements which remain after the fission process. It contains small amounts of unused uranium and isotopes of plutonium which have been created by neutron capture during the fission process. It also contains transuranic elements other than plutonium.[86] These nuclides are generally alpha-emitters, some of long half-life. Nuclear fuel in the reactor core is encased in rods which, after extraction of the spent fuel, must be chopped and chemically leached to remove fuel traces.[87]

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80. *See id.* at 351 (statement of Roger Mattson).

81. *See, e.g.*, ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, NUCLEAR ENERGY AGENCY, REVIEW OF THE CONTINUED SUITABILITY OF THE DUMPING SITE FOR RADIOACTIVE WASTE IN THE NORTH-EAST ATLANTIC 38 (1980).

82. *See* M. WILLRICH & R. LESTER, *supra* note 34, at 123. The actinides are the series of elements beginning with actinium and includes uranium and the known transuranics. *Id.* at 122. For information on select fission products, see NEA STUDY, *supra* note 10, at 28-29; DOE GENERIC EIS, *supra* note 20, at 4.11-4.13.

83. *See* NEA STUDY, *supra* note 8, at 28; M. WILLRICH & R. LESTER, *supra* note 34, at 2-3.

84. G. ROCHLIN, *supra* note 19, at 99.

85. Angino, *High Level and Long Lived Radioactive Waste Disposal*, 198 SCI. 885 (1977); Kubo & Rose, *Disposal of Nuclear Wastes*, 182 SCI. 1205, 1206 (1973).

86. These include neptunium (Np^{237}), americium (Am^{243}) and curium (Cm^{242}, Cm^{244}). DOE GENERIC EIS, *supra* note 20, at 4.12; NEA STUDY, *supra* note 8, at 28.

87. DOE GENERIC EIS, *supra* note 20, at 4.19.

The rods themselves also contain induced radioactivity.[88]

Spent fuel could itself be considered a waste,[89] but the spent fuel from conventional reactors has traditionally been considered an energy source because of its fissionable uranium and plutonium content.[90] In order to recover these elements, spent fuel could be chemically reprocessed, and its uranium and plutonium content recovered and refabricated into fresh fuel comprised of mixed oxides (MOx) of these two elements.[91] Other components of the waste could be further treated chemically to reduce their volume; the resulting "high level" waste from reprocessing would be stored briefly,[92] and then further conditioned for disposal. The further conditioning would probably involve solidifying the waste into a glass or ceramic "matrix" which would be packaged in containers. The containers would then be reposed in a suitable medium that would ensure satisfactory containment[93] even after the packaging became breached[94] and the waste form could no longer completely prevent migration of waste nuclides.[95]

Recovery of uranium and plutonium from spent fuel through reprocessing would greatly extend the period in which nuclear power could provide a major energy source.[96] But the prospect of the isolation of large amounts of plutonium has led to fears that

88. *See* M. WILLRICH & R. LESTER, *supra* note 34, at 122.

89. *Id.* at 4.11; NEA STUDY, *supra* note 8, at 29.

90. For a discussion of some of the issues involved in the decision to reprocess spent fuel, see M. WILLRICH & R. LESTER, *supra* note 34, at 27-31.

91. *See generally id.* at 34-39.

92. Current regulations of the NRC require solidification within five years of reprocessing. *See* 10 C.F.R. 50 app. F (1980).

93. The question of what standard of containment is satisfactory is somewhat subjective. *See* text at notes 108-16 *infra*. DOE's more abstract formulation is that "[t]he principal objective of waste disposal is to provide reasonable assurance that these wastes, in biologically significant concentrations, will be permanently isolated from the human environment." DOE GENERIC EIS, *supra* note 20, at 1.1.

94. Waste containment through packaging and incorporation into a leach-resistant waste form could probably last over 700 years, the period required for fission product decay to safe levels. *See* Nielsen, *Nuclear Waste Disposal in the Oceans*, 185 SCI. 1183 (1974); Nielsen, *Comparison of Some Geologic and Ocean Disposal Concepts Regarding Realistic Modelling that Allows Objective Risk Assessment to be Made*, in 1 SCIENTIFIC BASIS FOR NUCLEAR WASTE MANAGEMENT 549 (G. McCarthy ed. 1979).

95. Under the influence of chemical, thermal, and radiation factors the matrix is expected to allow nuclides to escape through leaching. G. ROCHLIN, *supra* note 19, at 95. The procedures for high level waste processing and disposal are elaborated on in the DOE GENERIC EIS, *supra* note 20, at ch. 4-5.

96. *See* 9 INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL NUCLEAR FUEL CYCLE EVALUATION 248-55 (1980) [hereinafter cited as 9 INFCE].

states not now possessing nuclear materials may have increased opportunities to acquire such materials and to use them in the construction of nuclear weapons. These concerns arise because plutonium has favorable characteristics for nuclear fission, even at low concentrations and because of the extra process and transportation steps associated with the recovery process.[97] These fears caused the U.S. Congress to tighten up U.S. nuclear export policies[98] and later led the Carter administration to impose a moratorium on commercial reprocessing and to defer indefinitely commercial use of the fast breeder reactor[99]—a device which could extend by a hundred times or more the potential of nuclear fission as an energy source by generating increased amounts of plutonium.[100] Other nations, including OECD members[101] and several less developed coun-

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97. *See* G. ROCHLIN, *supra* note 19, at 130-57. A commercial scale reprocessing plant would probably generate 250 kg of plutonium a year, and a research or pilot plant 10 kg. Only a few kilograms of plutonium would be sufficient to construct a nuclear explosive. *See id.* at 131, 141. There is a lively debate among experts, and among nations, concerning whether the decision to construct a nuclear explosive is primarily political and therefore unlikely to be affected by the presence of commercial operations that provide access to nuclear weapons-grade material, or whether the presence of such material is likely to provide an added incentive for construction of a weapon. *See generally* 9 INFCE, *supra* note 96, at 1. It is undeniable, however, that the advent of the plutonium economy will provide increased opportunities for access to nuclear weapons-grade material, both for states and political groups. Furthermore, regardless of the technical adequacy of safeguards preventing diversion of such material, the availability to states of such large quantities of weapons-grade material would decrease the lead time for effective political action by other states to prevent construction of a weapon. *See* G. ROCHLIN, *supra* note 19, at 135-36. On the other hand, it could be argued that without a sharing of reprocessing technology and access to supplies of mixed oxide fuel for more efficient nuclear reactors, including the fast breeder reactor, the fragile compromise represented by the Nonproliferation Treaty would crumble. This may have already begun. *See* notes 435-36 *infra*. The Treaty on the Non-Proliferation of Nuclear Weapons, *done* July 1, 1968, 21 U.S.T. 483, T.I.A.S. No. 6839, 729 U.N.T.S. 161 imposes reciprocal obligations on nuclear weapon and non-nuclear weapon states, the former to scale down the arms race and provide nuclear technology to the other states and the latter to refrain from developing or otherwise obtaining nuclear weapons.

98. *See* Nuclear Non-Proliferation Act of 1978, 22 U.S.C. §§ 3201-3224, 3241-3282; 42 U.S.C. §§ 2074-2094, 2139-2153(e), 2153(f), 2155-2160(a) (1973 & Supp. 1980).

99. Statement of President Carter, April 7, 1977, *reprinted in* 13 WEEKLY COMP. OF PRES. DOC. 502-04 (1977).

100. *See* 9 INFCE, *supra* note 96, at 6; M. WILLRICH & R. LESTER, *supra* note 34, at 31.

101. The U.S. actions led to political reactions by other OECD countries which were planning to develop commercial reprocessing services or to export reprocessing technology. A series of disagreements followed between the United States and other OECD members on proposed exports, which were compounded by commercial motivations, supply concerns, and differences of policy on the development and spread of nuclear technology. For a brief description of these events, see Power, *The Carter Anti-Plutonium Policy*, ENERGY POL., Sept. 1979, at 215. For an analysis of the motivations underlying the policy disagreements, see G. ROCHLIN, *supra* note 19, at 103-86.

tries,[102] signalled their disapproval of these policies, however, and have continued developing arrangements for full-scope national nuclear programs, spent fuel reprocessing, and the fast breeder reactor.[103] Although the term "high level waste" has been used primarily to refer to high level reprocessing wastes, it will be used here to refer to both these wastes and spent fuel if disposed of under national nuclear power programs. Estimates of waste concentrations and volumes will be given both in amounts of spent fuel and high level waste. However, depending on the waste treatment, spent fuel can have a volume about triple that of high level reprocessing wastes.[104]

By the end of 1980, the United States could have had on hand up to 10,000 metric tons (MT) of spent fuel had all reactor cores been discharged. Even with no growth in the nuclear industry, existing nuclear power plants could generate 48,000 MT over their lifetimes. Depending on projection of future growth of the industry, spent fuel could total between 239,000 and 427,000 MT by the year 2040.[105] For all the OECD countries, 15,000 MT could be generated annually by 1990. Reprocessing only half of this 15,000 MT would result in generation of about 750 cubic meters of solidified high level reprocessed waste annually.[106] World totals of spent fuel will probably amount to 300,000 MT by the year 2000.[107]

High level waste from nuclear fission contains hazardous substances that must be isolated from the environment for long periods of time.[108] Many approaches to the problems of isolation exist, for example, naturally occurring radioactive uranium ore could be used as a standard. Since human and other life evolved on earth in the presence of such ores (in fact during a period in which the level of radioactivity was much greater due to its constant decay), one could argue that high level waste could be brought into contact

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102. *See* notes 435-36 *infra*.

103. Estimates of the world growth of nuclear power programs, including fuel reprocessing and advanced fuel cycles such as the reactor U/Pu cycle in the fast breeder, are given in 9 INFCE, *supra* note 96, at 4-20, and an analysis of the necessary international institutions for cooperation among developed and between developed and less developed nations is given in *id.* at 44-53.

104. *See* DOE GENERIC EIS, *supra* note 20, at 4.46.

105. *Id.* at 3.13-3.14.

106. NEA STUDY, *supra* note 8, at 30.

107. *See* 9 INFCE, *supra* note 96, at 219.

108. *See* DOE GENERIC EIS, *supra* note 20, at 3.36-3.38; M. WILLRICH & R. LESTER, *supra* note 34, at 5-9.

with the environment when its radiological hazard is equivalent to that of a natural ore.[109] It would be sufficient to isolate the waste until its level of radioactivity reached such a naturally occurring level and thereafter allow it to become as exposed as the natural ore. Depending on the type of ore selected, however, the resulting period of isolation could range from three thousand (pitchblend) to several billion (0.2 per cent sandstone) years.[110]

Alternatively, the waste could be contained until the time at which diluting it in water until federal drinking water standards were met resulted in a volume of water (hazard index) equal to the mass of the ore mined to produce the fuel.[111] The total radioactivity would thus be transferred from one site (the mine site) to another (the repository). However, concentrated radioactivity at the repository would not necessarily present a hazard equal to the more diffuse radioactivity in the ore, regardless of their equal hazard indices.[112]

Another approach would be to compare the hazard index of high level waste with the toxicity of other naturally-occurring substances, such as the ores of mercury, lead, and silver.[113] High level waste has the same hazard index as rich mercury ore only a year after being discharged from the reactor; it has the same index as lead ores after about two hundred years. Again, though, hazard indices equal to these naturally-occurring substances do not mean

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109. M. WILLRICH & R. LESTER, *supra* note 34, at 6-7. Note that an ore is usually only remotely in contact with the living environment; similarly a high level waste repository by its location would probably provide partial isolation for a very long time. *Id.* at 7.

In comparing the hazards of radioactive waste to other toxic substances, it should be remembered that radioactive waste decays and becomes less dangerous over time, while many other substances—including minerals and some organic chemicals—do not. As a result of such decay, it is sometimes argued that absolute isolation of even high level radioactive waste would be required for only several hundred years. *See* Cohen, *The Disposal of Radioactive Wastes from Fission Reactors,* SCI. AM., June 1977, at 21. *But see* note 116 *infra,* & accompanying text.

110. M. WILLRICH & R. LESTER, *supra* note 34, at 7.

111. Recommended concentration guides have been established, for example by the U.S. Environmental Protection Agency, 10 C.F.R. 20.1-20.601, apps. A-D (1980) for radioactivity in water; these could provide a basis to compare the radiotoxicity of different substances or to compare the hazards of radiotoxic to other types of toxic agents.

112. *Id.* at 9. It could be argued in addition that provided wastes did not escape during a period of high radioactivity, their disposal would actually *decrease* human exposure to radioactivity since the uranium ore that was their ultimate source, and is also the primary source of radioactivity affecting man, would be removed from its natural occurrences. Cohen, *supra* note 109, at 30.

113. *See, e.g.,* DOE GENERIC EIS, *supra* note 20, at 3.36-3.38.

that the danger of transmission would be as low.[114]

Finally, the toxicity of high level waste could be compared to other toxic substances which are dispersed or which require disposal.[115] While the picture thus drawn would not be entirely accurate for the same reasons given above, such a procedure would put the high level waste question in a clearer perspective as against other toxic substance disposal issues.

Although none of these approaches is entirely satisfactory, they serve to put the problem of high level waste disposal into context. While it is impossible to state exact criteria, disposal of high level waste should provide isolation over periods ranging from 1,000 to several million years depending on the objectives and extent of confinement sought; a figure of one hundred thousand years is often given as the required time.[116]

In most countries with an embryonic disposal strategy, mined geological respositories are the favored solution although continued technical and political difficulties are expected.[117] Resort to the oceans is probable[118] for several reasons. First of all, greater scientific understanding of ocean processes may provide greater security in assessing the effects of disposal on the marine environment and rapidly developing marine technology may provide the means to design, implement, and monitor a disposal system.[119] Secondly, the

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114. *Id.* at 3.37-3.38.

115. *See, e.g.*, Cohen, *supra* note 109, at 27, 30.

116. G. ROCHLIN, *supra* note 19, at 100.

117. At present, no disposal facilities for commercially generated high level waste exist in OECD nations. *See* NEA STUDY, *supra* note 8, at 11. Several states, including Sweden and Austria, have made formalistic decisions on ultimate disposal based on the need to satisfy legal requirements that such disposal methodologies be available before additional nuclear reactors are installed. There has been strenuous public opposition, however, to the Asse test facility and proposed commercial operations planned for Gorleben, both in the Federal Republic of Germany. Salander, Proske & Albrecht, *The Asse Salt Mine, the World's only test facility for the disposal of Radioactive Waste*, 5 INTERDISCIPLINARY SCI. REV. 292, 298, 302-03 (1980).

The United States DOE has recently issued a final environmental impact statement in which mined geological repositories are chosen as the primary method of disposal, with continued development being accorded to other concepts—especially the seabed and deep drilled holes. *See* DOE GENERIC EIS, *supra* note 20; notes 134-36 *infra* & accompanying text.

For an account of various states' approaches to regulating underground disposal, see International Atomic Energy Agency, Regulatory Aspects of Underground Disposal of Radioactive Waste, IAEA Doc. IAEA-TECDOC-230 (1980).

118. *See* 1980 *Hearings*, *supra* note 1, at 467-69 (prepared statement of Clifton Curtis) (criticizing the choice of ocean dumping as neither socially or economically desirable).

119. *See generally* 1980 *Hearings*, *supra* note 1, at 296-302 (statement of Sheldon

sediments of the deep seabed in certain areas, which would tend to trap released radionuclides from high level waste,[120] constitute one of the most geologically stable environments in the world.[121] Thirdly, the oceans would provide a medium of dilution for any wastes released from a repository.[122] Fourthly, partial or complete reliance on the oceans could meet qualitative criteria such as multiplicity of sites and resistance to future human intrusion.[123] Finally, repository location in the oceans could decrease domestic political pressures associated with choice of a continental repository location.[124]

Several countries are studying the possibility of locating waste repositories in the oceans. Such disposal of high level waste could take several forms, including "emplacement" of such waste in the deep ocean.[125] The United States has indicated[126] that it will continue to develop the concept of burial of such waste in the sediments of the deep seabed (seabed emplacement); it has obtained the cooperation of several other OECD countries at the technical level.[127] The United Kingdom has supported studies of improved dumping, with better containment, that would result in disposal on the deep seafloor (seafloor emplacement).[128] Several Western Euro-

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Meyers).

120. *See* notes 142-47 *infra* & accompanying text.

121. *See, e.g.*, Hollister, *The Seabed Option*, OCEANUS, Winter, 1977, at 18.

122. Regardless of whether the ocean itself is technically considered as a barrier to the transmission of disposed wastes to man or significant ecosystems, the decision to locate a repository in the oceans would probably be motivated in great part by this factor. *See* text at notes 148-51 *infra*.

123. *See generally* Rochlin, *Nuclear Waste Disposal: Two Social Criteria*, 195 SCI. 23 (1977).

124. *See* 1980 *Hearings*, *supra* note 1, at 454 (statement of James P. Walsh); *id.*, at 469 (statement of Clifton Curtis).

125. The term "emplacement" is used here to distinguish such disposal of high level waste from the methods that have been used to dispose of low level waste, *i.e.*, "dumping" of wastes onto the seafloor by jettisoning from ships. *See* text at notes 50-72 *infra*. At the minimum, emplacement would require improved planning, environmental assessment, containment, and postoperational monitoring; it could also involve burial in sediments. *See* text at notes 134-51, *infra*.

126. According to the DOE GENERIC EIS, *supra* note 20, the DOE proposes action to emphasize development of a continental geological repository while continuing development of the seabed emplacement and continental deep hole injection concepts. *Id.* at 1.6. For a fuller description of seabed emplacement, see text at notes 134-51 *infra*.

127. A Seabed Working Group has been established within the Radioactive Waste Management Committee of the NEA, including participants from Canada, France, Japan, the Netherlands, the United Kingdom, and the United States and observers from the Federal Republic of Germany and Switzerland.

128. The National Radiological Protection Board has been asked by British Nuclear Fuel,

pean and American authorities have shown an interest in a variety of ocean disposal methods—including deep seabed[129] and seafloor[130] emplacement, disposal on or in the continental shelf,[131] the mining of geological repositories on islands,[132] and the construction of artificial islands on the continental shelf.[133]

Perhaps the most developed of such concepts at present is seabed emplacement. The United States Department of Energy (DOE)[134] and other government agencies[135] have sponsored considerable research in this area. Seabed emplacement had earlier been identified by the Carter administration as a future alternative to mined geological disposal; it has now been selected by the DOE for continued development and possible future use even though that agency will proceed to implement its primary strategy—mined continental geological repositories.[136] The concept of seabed emplacement envisions emplanting waste in the clayey sediments of the deep seabed (abyssal plains) in areas remote from the geologically unstable rims of tectonic plates and the great current gyres

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Ltd. to study the radiological consequences of seafloor emplacement. ROYAL COMMISSION REPORT, *supra* note 37, at 149.

129. *See, e.g.*, ROYAL COMMISSION REPORT, *supra* note 37, at 155-60; note 127 *supra*.

130. *See, e.g.*, Preston, in Otaniemi Symposium, *supra* note 9, at 3, 15. *See also* text at note 128 *supra*.

131. In Europe, some suitable geological formations such as salt domes are located on the continental shelf beneath the North Sea. ROYAL COMMISSION REPORT, *supra* note 37, at 153.

132. *See, e.g.*, DOE GENERIC EIS, *supra* note 20, at 6.48-6.61; ROYAL COMMISSION REPORT, *supra* note 37, at 154.

133. *See* text at note 150 *infra*.

134. *See* 1980 *Hearings, supra* note 1, at 273, 296-99 (statement of Sheldon Meyers). The Seabed Disposal Program of DOE, which is working on this concept, has been funded since 1974; its budgets for 1980 and 1981 (planned) are about $7 million per year. *Id.* at 298. *See generally* SANDIA LABORATORIES, SEABED PROGRAMS DIVISION, SUBSEABED DISPOSAL PROGRAM PLAN (1980) [hereinafter cited as SDP PLAN].

135. The National Oceanic and Atmospheric Administration (NOAA) has funded research related to seabed emplacement and may soon enter into a memorandum of understanding with DOE concerning coordinated research. 1980 *Hearings, supra* note 1, at 454-58 (statement by James P. Walsh).

136. DOE's proposed action is "to select and pursue a programmatic strategy that would lead to disposal of . . . high-level and transuranic wastes in mined repositories in geologic formations. . . . The programmatic strategy will direct effort and concentrate resources on a research and development program leading to repositories and to site-selection processes. Some support will be provided to further evaluate the alternatives of subseabed disposal and disposal in very deep holes." DOE GENERIC EIS, *supra* note 20, at 1.7. The chief alternative to this action was balanced development of several strategies—including mined geological repositories, seabed emplacement, and deep hole injection. *Id.* at 1.16-1.20. *See also* 1980 *Hearings, supra* note 1, at 273, 300-301 (statement of Sheldon Meyers) (seabed emplacement a possible future supplementary approach).

around the ocean basins that are associated with areas of high biological productivity. Emplantation would be by mechanical means, most likely[137] through penetration by gravity projectiles (penetrometers).[138] Operational monitoring would occur at least to the extent required to ensure that correct placement was achieved and that the sediments around the waste canister returned to a satisfactory state.[139] Although no retrieval capacity is currently planned, it would be possible to retrieve implanted waste canisters—at considerable expense—by relocating them remotely and recovering them in a drilled core (overcoring).[140] All of these operations appear to be within the range of existing technology, although some of the operations would be difficult and expensive due to the depth of the disposal site—4000-6000 meters.[141]

The essence of the seabed emplacement concept is that the deep seabed sediments would provide a waste disposal medium similar to that sought in geological formations on the continents[142]—*i.e.*, a natural medium that would retain its structural integrity despite exposure to intense heat and radioactivity, would be stable over the long term, and would isolate wastes from the environment.[143] The isolation would be provided by the low porosity and chemically active nature of the sediments. Wastes released from their primary containment would be unlikely to migrate to the vicinity of the sea floor because of the resistance of the sediments to physical capillary movement and because waste nuclides would tend to become chemically bound to the particles of these clays (adsorption).[144] Aside from the effect of penetration on the sediments,[145]

137. Other possibilities include winch controlled fall and penetration, drilled holes, and trenching; some of these methods might require backfilling. Silva, *Physical Processes in Deep-Sea Clays*, OCEANUS, Winter 1977, 31, 36-37; Valent & Lee, *Feasibility of Subseafloor Emplacement of Nuclear Waste*, in 1 MARINE GEOTECHNOLOGY 267 (1976).

138. DOE GENERIC EIS, *supra* note 20, at 6.67.

139. *Id.* at 6.68-6.71. *Cf.* 1 SDP PLAN, *supra* note 134, at 17 (surveillance as long as is necessary to "protect or reassure" the public).

140. DOE GENERIC EIS, *supra* note 20, at 6.68; 1 SDP PLAN, *supra* note 134, at 20.

141. *See generally* DOE GENERIC EIS, *supra* note 20, at 6.68-6.70.

142. DOE and its predecessor agency, the Energy Research and Development Agency (ERDA) have taken the position that seabed emplacement is a form of geological disposal and is unlike sea dumping. *See* 1980 *Hearings*, *supra* note 1, at 297-98 (statement of Sheldon Meyers); notes 514-15 *infra*.

143. *See* 1 SDP PLAN, *supra* note 134, at 8-9.

144. DOE GENERIC EIS, *supra* note 20, at 6.63, 6.66; Heath, *Barriers to Radioactive Waste Migration*, OCEANUS, Winter 1977, at 26.

145. *See* DOE GENERIC EIS, *supra* note 20, at 6.70.

the chief technical issues to be resolved about the medium itself involve the response of the sediments near the canister to high heat; the possibility of convection currents in the sediments resulting from the heat; and the ability of the sediments to absorb and retain the radionuclides.[146] Chemical adsorption cannot be effective for all waste nuclides or all forms of waste disposal.[147]

Other ocean disposal concepts for high level waste, like seabed emplacement, rely to a greater or lesser extent on potential dilution of released wastes by the ocean. Seafloor emplacement would rely on marine dispersion after the failure of containment, probably at best after decay of most fission product activity.[148] In this respect it appears to be on a continuum with existing sea dumping practices.[149] Geological repositories constructed on sea islands or in continental shelf geological formations reached by drilling from natural or artificial islands rely primarily on geological isolation.[150] Nevertheless they derive some of their attractiveness by the greater ease of detecting and evaluating releases into the overlying waters and the dispersion of any released wastes in the marine environment.[151]

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146. SDP PLAN, *supra* note 134, at 36-40.

147. Iodine and technetium would not be absorbed into sediments. DOE GENERIC EIS, *supra* note 20, at 6.62. Both are long-lived fission products. *See* NEA STUDY, *supra* note 8, at 28.

148. Proponents of seafloor emplacement have stressed the potential acceptability of high level waste disposal in this manner with improved containment and possibly partioning of the high level waste to remove long-lived radionuclides. An NEA expert group has concluded that, based on present knowledge, if such containment could be assured "over the hazardous lifetime of most fission products," there would be little deleterious effect on the environment. NEA STUDY, *supra* note 8, at 55-56.

149. *See* notes 361-71 *infra* & accompanying text.

150. DOE GENERIC EIS, *supra* note 20, at 6.48. For a general discussion of island disposal, *see id.* at 6.48-6.61.

151. Releases from mined geological repositories on sea islands or drilled holes from natural or artificial islands on the continental shelf could be detected around the coastline of the island or the seabed adjacent to the island, depending on the location of the repository and the most likely means of physical transport. *See* DOE GENERIC EIS, *supra* note 20, at 6.59; ROYAL COMMISSION REPORT, *supra* note 37, at 154 (natural island mined geological repository). This could provide an advantage over continental sites which generate fear of the uncertainties about the transport of released waste by unpredictable ground water routes. *See* DOE GENERIC EIS, *supra* note 20, at 5.17-5.19.

II. OCEAN DISPOSAL OF RADIOACTIVE WASTES UNDER INTERNATIONAL LAW[152]

General international law on the environment and natural resources, the emerging law of the sea and the institutional history of ocean disposal of radioactive wastes all support the claim that a special international law of cooperation exists for ocean disposal of radioactive wastes.[153] When the first United Nations Conference on the Law of the Sea (UNCLOS I) convened in 1958, many nations had concluded that some form of regulation was required of practices that could lead to marine pollution by radioactive substances.[154] Accordingly, UNCLOS I adopted Article 25 of the Ge-

152. Several articles have appeared on this subject in U.S. law journals, but most are now outdated or of limited scope. *See* Brown, *International Law and Marine Pollution: Radioactive Waste and 'Other Hazardous Substances'*, 11 NAT. RESOURCES J. 221 (1971); Note, *International Law and Radioactive Pollution by Ocean Dumping: 'With All Their Genius and With All Their Skill . . .'*, 11 SAN DIEGO L. REV. 757 (1974). More useful analyses may be found in the Continental sources, *passim*. One article which recently appeared in a U.S. source requires special scrutiny: Lomio, *International Law and Disposal of Radioactive Wastes at Sea*, 15 NEW ENG. L. REV. 253 (1980). The technical material in this article is somewhat incomplete and the conclusions drawn from such a background can be misleading. Many definitional problems in the legal context arise because of the imprecise technical approach and because of other apparent inaccuracies.

153. Earlier and greater international concern and attention has been given to radioactive substances than to any other marine pollutant except oil released from ships. *See* note 12, *supra*. For example, nuclear weapons tests conducted by the United States between 1946 and 1954 occurred on sea islands and involved closing areas of the high seas during testing periods. The factual situation concerning these tests is extensively described in legally significant terms in McDougal & Schlei, *The Hydrogen Bomb Tests in Perspective: Lawful Measures for Security*, 64 YALE L.J. 648 (1955). The resultant fallout and interference with navigation and fishing sparked a debate on whether such tests were a permissible use of the high seas. The article from the scholarly controversy which still survives is that of McDougal and Schlei, *id*. These authors justified the tests as a "reasonable use" of the high seas, both in terms of the resulting pollution and interference with navigation and fishing, in view of the contemporary international security situation and the then remoteness of the test site. It has been commented that for such a reasonable use McDougal and Schlei required an inordinate amount of analysis (and paper) to defend it. *See* J. BALLENEGGER, LA POLLUTION EN DROIT INTERNATIONAL 158 n.6 (1975). Atmospheric nuclear tests have been the largest contributor of artificial radioactivity to the sea, contributing about a thousand times as much long lived radioactivity as from other nuclear operations. IAEA Definition and Recommendations, *supra* note 17, ¶ 2.2.7. Civilian nuclear operations account for only a small fraction of these operational releases and less than one thousandth of the natural radioactivity of the sea. *Id.* Although small in quantity these releases are localized and therefore should be evaluated and controlled carefully. *Id.* ¶ 2.2.5. Dumping of radioactive wastes at sea began in 1946 and discharges from nuclear reactors and other facilities into coastal waters began even sooner, in the early 1940's with the construction and operation of military nuclear plants. *See* Osterberg, *supra* note 30, at 26.

154. The views of several states, as they emerged during UNCLOS I, are summarized in

neva Convention on the High Seas:[155]

> 1. Every State shall take measures to prevent pollution of the seas from the dumping of radio-active waste, taking into account any standards and regulations which may be formulated by the competent international organizations.
> 2. All States shall cooperate with the competent international organizations in taking measures for the prevention of pollution of the seas or air space above, resulting from any activities with radio-active materials or other harmful agents.

Although unable to reach agreement on the subject of nuclear weapons testing, UNCLOS I recognized "the need for international action in the field of disposal of radio-active wastes in the sea."[156] In addition, the Conference noted the recommendations made by the ICRP on human dose and environmental concentrations of radionuclides, and recommended that the International Atomic Energy Agency (IAEA), along with other organizations

> pursue whatever studies and take whatever action is necessary to assist States in controlling the discharge or release of radio-active materials to the sea, in promulgating standards, and in drawing up internationally acceptable regulations to prevent pollution of the sea by radio-active materials in amounts which would adversely affect man and his marine resources.[157]

Various interpretations have been offered as to the legal significance of these results of UNCLOS I. Despite the opposition of certain states to any dumping of radioactive wastes, UNCLOS I was

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M. McDOUGAL & W. BURKE, THE PUBLIC ORDER OF THE OCEANS 864-67 (1962). The Soviet Union favored a complete prohibition of nuclear waste dumping. *See* U.N. Doc. A/CONF.13/C.2/L.118, at 149. It now takes the position that although radioactive waste dumping should be prohibited it cannot be avoided completely at present but should be minimized and carried out in accordance with standards developed by the London Convention parties in consultation and by the IAEA. *See* LDC-V report, *supra* n.5, at 12.

155. Geneva Convention on the High Seas, *done* April 28, 1959, 13 U.S.T. 2312, T.I.A.S. No. 5200, 450 U.N.T.S. 82.

156. Resolutions Adopted By the United Nations Conference on the Law of the Sea, Pollution of the High Seas by Radio-active Materials, 450 U.N.T.S. 58, Apr. 27, 1958. UNCLOS I, unable to reach agreement on the subject of nuclear tests, adopted a resolution on this matter as well, referring it to the United Nations General Assembly. *Id. See* M. McDOUGAL & W. BURKE, *supra* note 154, at 864-65.

157. 450 U.N.T.S. 58, Apr. 27, 1958.

unable to prohibit the practice or even to formulate substantive standards. McDougal and Burke have interpreted Article 25 as containing therefore merely "admonishments to states to cooperate" while the failure to prohibit sea dumping "contemplated the possibility that under proper conditions disposal can be considered a reasonable use of the sea."[158] Other commentators have suggested that the actions of UNCLOS I resulted in an obligation to engage in cooperative scientific development of substantive norms for dumping and establishment of international controls to ensure that States do not authorize activities that would endanger human health.[159] It has even been claimed that Article 25 constitutes the first international "recognition"[160] of sea dumping which conforms with these conditions, an assertion which has gained credibility as various international arrangements have been made to regulate this activity.[161] Article 25 has been set forth by commentators as proof of the existence of a customary law of international cooperation with regard to ocean disposal of radioactive wastes, especially sea dumping.[162]

Beginning the long history of involvement by international organizations in this field, the IAEA immediately convened a group of experts on ocean disposal of radioactive waste whose report (the Brynielsson report) was adopted by the IAEA in 1961. The conclusions of the Brynielsson report were, briefly, that ocean disposal of

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158. M. McDOUGAL & W. BURKE, *supra* note 154, at 867.

159. *See, e.g.,* Reyners, *supra* note 75, at 102-103; Courteix, *Droit nucleaire et droit oceanique: Une synthese,* in NUCLEAR INTER JURA '75 71, 78-79 (1975).

160. Preston, in Otaniemi Symposium *supra* note 9, at 3, 15. McDougal and Burke reached a similar conclusion based only on the then practice of states and their own interpretation of what would be reasonable in the circumstances. M. McDOUGAL & W. BURKE, *supra* note 154 at 854-57.

161. *See* Preston, in Otaniemi Symposium, *supra* note 9.

162. *See* Reyners, *supra* note 75, at 103. McDougal and Burke reach a similar result while eschewing the legal significance of Article 25 and the accompanying resolution of UNCLOS I. They point to a consensus in the international scientific community regarding the necessity of international agreement about disposal operations. M. McDOUGAL & W. BURKE, *supra* note 154, at 855. Given their conclusion that in disposing of radioactive waste at sea states should restrict their activities according to scientific determinations, *id.*, then one could argue that international cooperation in scientific study and formulation of standards would be required as a prerequisite of reasonableness for proposed operations. If the ordinary mechanism of international scientific cooperation were through international organizations, participation in the functions of such organizations would then also appear to be a prerequisite of fulfilling the obligation of reasonableness in conducting such high seas activities. This conclusion is supported by the resolution of UNCLOS I, and by the general role these organizations are assuming in the developing law of the sea, see text at note 214 *infra*.

high level wastes could not be recommended; that low level wastes should be dumped only under controlled and specific conditions; and that such dumping operations should be conducted on a site-specific basis. The report emphasized that these conclusions were provisional and accompanied them by several recommendations, including that certain operational controls be adopted through actions in international organizations. Specifically suggested actions were certification and international registration of dumped wastes, designation of dump sites, and establishment of operational procedures for dumping. The Brynielsson report proposed that its findings be taken as the basis for an international agreement on the matter.[163]

The IAEA also convened, in 1960, an international legal group (the Rousseau group) to consider legal and administrative matters related to the Brynielsson report.[164] This group was, however, unable to reach a consensus;[165] a minority contended that all ocean disposal of radioactive wastes was prohibited. The majority, finding that they were mandated to formulate provisions based on the conclusions of the Brynielsson report, called for establishment of international procedures—preferably through the IAEA—for notification of national disposal plans and operations on the high seas, in any territorial sea, or into the internal waters of another State. The majority of the Rousseau group also followed the Brynielsson report in excluding high level waste disposal by dumping and proposing that dump sites have a depth of at least 2000 meters.

Although the Rousseau group failed to agree on international measures to regulate ocean disposal of radioactive wastes, such wastes remained subject to a higher level of national control than others[166] through the comprehensive authority to control radioactive materials granted to national atomic energy authorities.[167] In

163. Ad Hoc Experts Group on the Disposal of Radioactive Wastes at Sea, chaired by H. Brynielsson. *See* IAEA, RADIOACTIVE WASTE DISPOSAL INTO THE SEA (1961) (Safety Ser. No. 5).

164. For a general description of the proceedings of this group, see Reyners, *supra* note 75, at 106-107. *See also* du Pontavice, *Reflexions sur la pollution maritime d'origine radioactive*, LE DROIT MARITIME FRANCAIS 643, 654 (Nov. 1976).

165. The Rosseau group reported to the IAEA in 1963, presenting majority and minority positions. Their report, IAEA Doc. DG/WDS/L.19 (June 19, 1963), was not publicly released by the IAEA. It has been discussed by several authors, however. *See, e.g.*, Reyners, *supra* note 75, at 107.

166. *See* Böhme, *supra* note 9, at 93, 105.

167. *See* Reyners, *supra* note 75, at 100.

1972, the Stockholm Conference[168] adopted a principle calling on States to prevent marine pollution[169] and a recommendation that national authority be exercised to control ocean dumping and that a global instrument be concluded on this subject.[170]

When the London Convention was adopted in 1972,[171] such international control became possible. Under the London Convention, the dumping at sea of high level radioactive waste or matter is prohibited as listed in Annex I[172] and special permits must be issued by national authorities for the dumping of other radioactive waste or matter, which is listed in Annex II.[173] In issuing permits, national authorities are to give careful consideration to factors specified in Annex III, including prior studies of the dumping site.[174] For radioactive wastes included in Annex II, parties should take full account of the recommendations of the competent international organization—the IAEA.[175] Parties notify the Intergovernmental Maritime Consultative Organization (IMCO), which has been designated the secretariat of the Convention, of the permits they have issued[176] and IMCO reports this information.[177]

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168. The United Nations Conference on the Human Environment, Stockholm, June 5-16, 1972. *See* Report of the United Nations Conference on the Human Environment, U.N. Doc. A/CONF. 48/14/Corr.1 (1972) [hereinafter cited as Stockholm Conference Report]. For a description of the conference and its background and results as well as an analysis of the principles it adopted, see generally Sohn, *The Stockholm Declaration on the Human Environment,* 14 HARV. INT'L L.J. 423 (1973).

169. Principle 7: "States shall take all possible steps to prevent pollution of the seas by substances that are liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea." Stockholm Conference Report, *supra* note 168, at 4.

170. Recommendation 86(c), *id.* at 22. In Recommendation 75, *id.* at 20, the Conference recommended that governments should:

> (a) Explore with the International Atomic Energy Agency and the World Health Organization the feasibility of developing a registry of releases to the biosphere of significant quantities of radioactive materials;
>
> (b) Support and expand, under the International Atomic Energy Agency and appropriate international organizations, international co-operation on radioactive waste problems . . . .

171. *See* text at note 74 *supra*.

172. London Convention, *supra* note 6, art. IV(1)(a), Annex I (6). High level radioactive waste or matter is "defined on public health, biological or other grounds, by the competent international body in this field, at present the International Atomic Energy Agency, as unsuitable for dumping at sea." *Id.*

173. *Id.* art. IV(1)(b), Annex II (D).

174. *Id.* art. IV(2).

175. *Id.* Annex II (D).

176. *Id.* art. VI.

177. *Id.* art. XIV(3)(d). Since the signing of the London Convention, additional regional

The IAEA recommendations on low level waste dumping mandated by Annex II of the London Convention, most recently issued in 1978,[178] contain a basis for issuance of special permits on such operations. The recommendations call for "a detailed environmental and ecological assessment" on each application.[179] Proposed operations should conform with the ICRP principles.[180] Upper limits on total releases in a single ocean basin are given,[181] and the importance of isolation and containment of waste through suitable packaging are stressed.[182]

According to the IAEA, the required environmental assessments

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conventions have been adopted which provide for various forms of regional cooperation in certain areas. *See, e.g.*, Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution, Apr. 23, 1978, *reprinted in* 17 INT'L LEGAL MATERIALS 511 (1978) [hereinafter cited as Kuwait Convention]. Convention for the Protection of the Mediterranean Sea Against Pollution and Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft, Feb. 16, 1976 *reprinted in* 15 INT'L LEGAL MATERIALS 290, 300 (1976) [hereinafter cited as Barcelona Protocol]; Convention on the Protection of the Marine Environment of the Baltic Sea Area, *done* March 22, 1974 (not in force) *reprinted in* 13 INT'L LEGAL MATERIALS 546 (1974) [hereinafter cited as Helsinki Convention].

These agreements provide a vehicle for more stringent control of dumping and other practices and provide a regional focus for efforts against marine pollution. *See, e.g.*, Kuwait Convention, art. V (appropriate national measures to control dumping, including effective compliance with applicable international rules as provided in international conventions). Barcelona Protocol, art. 4 & Annex I (prohibition on dumping certain substances, including high, medium, or low level radioactive wastes as defined by the IAEA or other matter), art. 5 & Annex II (special permits required for dumping certain other substances, including other radioactive waste or matter), art. 6 (general permits required for dumping all other substances), and art. 7 & Annex III (careful consideration of certain factors in issuing dumping permits); Helsinki Convention, art. 5 & Annex I (prohibition or regulation of introduction of certain substances into marine environment), art. 6 & Annex II (special permits for introduction of certain other substances, including radioactive substances), art. 9 (prohibition on dumping except of dredged spoils), & Annex V (criteria to be considered in permitting discharges or dumping).

Parties to the London Convention can provide required notifications indirectly through their regional organizations. London Convention, *supra* note 5, art. VI(4). *See also id.* art. VIII (parties should enter into regional arrangements to further the objectives of the Convention; procedures under the Convention and these arrangements should be harmonized).

178. *See* IAEA Definition and Recommendations, *supra* note 17; text at notes 289-92, 312-34 *infra*. The IAEA issued its first recommendations on low level waste dumping along with its definition of high level waste unsuitable for dumping at sea in 1975. International Atomic Energy Agency, Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, the Definition Required by Annex I, paragraph 6 to the Convention and the Recommendations Required by Annex II, Section D, IAEA Doc. INFCIRC/205/Add.1 (1975) [hereinafter cited as IAEA Provisional Definitions and Recommendations].

179. IAEA Definition and Recommendations, *supra* note 17, at ¶ B.1.1.

180. *Id.* ¶ B.1.2.

181. *Id.*

182. *Id.* ¶ B.1.3.

should be communicated to IMCO along with the notifications of dumping required under the London Convention.[183] They should include consideration *inter alia* of the justification for dumping as opposed to land alternatives, including geological and physical factors at the dumpsite which could affect waste transport.[184] In addition, the assessment should contain information on likely doses to humans and risks to marine ecosystems and the degree to which exposures could be limited by waste conditioning, containment, or selection of a favorable site. As to the sites themselves, they should be chosen as to be away from areas of fishery trawling, cables in use, areas of navigational difficulties and areas of biological productivity or potential seabed resources. Sites should be located below 50° latitude and have a depth greater than 4000 meters; they should be away from continental margins, islands, and other geologically unsuitable areas. Designated sites should be as small as possible but never more than 10,000 square kilometers. The number of sites should be strictly limited.[185] After dumping, monitoring should be undertaken in the vicinity of the dumpsite.[186] Since the adoption of the London Convention, the regulatory efforts of the IAEA with respect to ocean disposal have been primarily directed toward its responsibilities under the Convention with respect to sea dumping.[187]

Ocean disposal of radioactive wastes must be viewed in the context of the emerging international law on the environment, natural resources, and the marine environment and resources in particular. But the law governing nuclear activities has developed more rapidly than environmental law and has been characterized by strong State intervention, international cooperation, an emphasis on risk prevention, and special provisions for responsibility.[188] Generally,

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183. *Id.* ¶ B.1.5. *See* note 177 *supra*.

184. IAEA Definition and Recommendations, *supra* note 17, ¶ B.1.4.

185. *Id.* § C.2.

186. *Id.* § B.2.

187. *See* notes 178-86 *supra*. IAEA also has responsibilities under the protocol on dumping to the Barcelona Convention, *see* note 177 *supra*, and may acquire similar responsibilities under other regional agreements. The Director General of the IAEA has indicated that the agency may require financial assistance to undertake such additional responsibilities. See IAEA Doc. GOV/1820 (Jan. 28, 1977), Annex at 5. The IAEA has promoted international scientific exchanges on ocean disposal of radioactive wastes. *See, e.g.*, Vienna Symposium, *infra* note 349; San Francisco Symposium, *supra* note 40; Seattle Symposium, *supra* note 46; Otaniemi Symposium, *supra* note 9.

188. *See* Orol, Environment and Nuclear Law from the Lawyer's Point of View (in Spanish), in IAEA, *Application of Environmental Impact Analysis to the Nuclear Power*

the law regarding certain nuclear activities has tended to follow the pattern established in maritime law for ships carrying oil and other polluting substances.[189] Unlike other nuclear activities, however, no specialized agreements have been concluded on liability for damages resulting from ocean disposal.[190] Presumably, this relates to the difficulty of ascribing liability and assessing damages for any injuries allegedly suffered as a result of such activities.[191] Therefore, regulation of ocean disposal assumes chief legal importance,[192] for this reason as well as because of the potentially serious and long-lived nature of the environmental harm in case injury were to occur.[193]

Proper international regulation of ocean disposal could prevent inconsistent policies being pursued by individual nations. Inconsistencies could occur, for example, if the policies of one State contributed to high doses to humans or valuable living marine resources of another State, or interfered with that State's

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Industry, Aug. 29-Sept. 2, 1977, at 307.

189. *See* du Pontavice, *supra* note 164, at 646. Special international agreements govern the liability of nuclear facilities operators. *See* Vienna Convention on Civil Liability for Nuclear Damage, May 21, 1963, *reprinted in* 2 INT'L LEGAL MATERIALS 727 (1963); Brussels Convention, Supplementary to Paris Convention on Third Party Liability in the Field of Nuclear Energy, Jan. 31, 1963, *reprinted in* 2 INT'L LEGAL MATERIALS 685 (1963); Paris Convention on Third Party Liability in the Field of Nuclear Energy, July 29, 1960, *reprinted in* 55 AM. J. INT'L L. 1082 (1961). Additional special agreements control the liability of maritime carriers of nuclear materials, see note 27, *supra*, and operators of nuclear powered vessels, see Brussels Convention on the Liability of Operators of Nuclear Ships, May 25, 1962, *reprinted in* 57 AM. J. INT'L L. 268 (1963). For other special agreements on contingency operations for nuclear facilities in border areas, see note 623, *infra*.

Radioactive substances are also subject to general maritime instruments. *See, e.g.*, Kuwait Convention, *supra* note 177; Barcelona Protocol, *supra* note 177; Helsinki Convention, *supra* note 177; Oslo Convention, *supra* note 73; London Convention, *supra* note 5.

Under the International Convention on the Safety of Life at Sea (SOLAS), which establishes design, equipment and construction standards for ships, radioactive materials have been classified as Class 7 dangerous goods. As such they are subject to the applicable safety standards found in the IMCO International Maritime Dangerous Goods Code (IMDGC). *See* Note, *International Conventions Relating to Radioactive Marine Pollution*, 13 NUCLEAR L. BULL. 39, 43-45, (1974).

The International Convention on Pollution of the Sea by Oil (MARPOL) has controlled operational discharges from vessels, especially tank vessels, since 1954. MARPOL does not explicitly cover radioactive effluents, however. For a general discussion of the MARPOL Convention, and especially the pending 1978 amendments, see M'GONIGLE & ZACHER, POLLUTION, POLITICS AND INTERNATIONAL LAW 107-122 (1979).

190. *See* du Pontavice, *supra* note 164, at 645-47.

191. *See* J. BALLENEGGER, *supra* note 153, at 155-57.

192. *See* Hardy, *International Control of Marine Pollution*, 11 NAT. RESOURCES J. 296, 312 n.44 (1971).

193. *Id. See* du Pontavice, *supra* note 164, at 647-48.

policies on maritime development. Conceptually, such a problem could occur whenever the disposal policies of one State interfered with another State's rights to common property resources (such as high seas fisheries), to jointly controlled resources (such as the resources of international river basins or migratory fish species), to its own resources (the environment of its coast and territorial sea or the living resources of its economic zone), or to potentially internationally owned resources (such as the mineral resources of the deep seabed).[194]

Ocean disposal of radioactive waste would be subject to international law in appropriate circumstances as a source of marine pollution. The most broadly accepted definition of marine pollution,[195] derived by the United Nations interagency Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP),[196] is included in the current Draft Convention on the Law of the Sea (Draft LOS Convention) now being developed:

> Pollution of the marine environment means the the introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities.[197]

What is noteworthy about this definition is that it is phrased primarily in terms of human uses of the sea and its resources.[198] These protected uses must be seen, in turn, as referring to the in-

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194. For a description and discussion of this classification, see Bilder, *International Law and Natural Resources Policies,* 20 NAT. RESOURCES J. 451, 452-65 (1980).

195. GESAMP, Comprehensive Outline of the Scope of the Long-Term and Expanded Program of Oceanic Exploration and Research, U.N. Doc. A/7750, Part I, 3, Nov. 10, 1969. *See* Hardy, *supra* note 192, at 299, n.4.

196. GESAMP is composed of experts contributed by the Intergovernmental Maritime Consultative Organization (IMCO), the Food and Agriculture Organization (FAO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Meterological Organization (WMO), the World Health Organization (WHO), and the IAEA. *See also* note 433, *infra* & accompanying text.

197. United Nations Third Conference on the Law of the Sea, Draft Convention on the Law of the Sea, (Informal Text), art. 1(4), U.N. Doc. A/CONF.62/WP.10/Rev.3 (1980).

198. *See generally* Springer, *Towards a Meaningful Concept of Pollution in International Law,* 26 INT'L & COMP. L.Q. 531, 537-51 (1977).

terests of States,[199] since if no State interest were violated by an alleged act of marine pollution, no claim could arise under international law.[200] The interests of States in the environment and marine resources can arise only in the four situations of potentially inconsistent national policies enumerated above.[201] The legality of ocean disposal would therefore have to be assessed with respect to its effect on State interests which arise under these bases of entitlement.

In the *Nuclear Tests Cases,* the International Court of Justice (ICJ) based its preliminary measures of protection[202] prohibiting continued testing on the fact that the significant amounts of radioactive fallout from France's proposed atmospheric tests on Pacific islands would be transported to the national territory of Australia,[203] New Zealand,[204] and their Pacific island territories. The ICJ never had to adjudicate the plaintiffs' claim that fallout from the tests would be an infringement on their territorial sovereignty, based on its later conclusion that France had committed itself not to undertake further atmospheric testing[205] and since the plaintiffs had not claimed damages from the tests which were conducted in violation of the Court's preliminary order.[206] The Court's preliminary findings nevertheless illustrate how a claim of nuclear pollution can be based on an identifiable national interest—in this case infringement of national sovereignty over domestic territory.[207] Although the plaintiffs also argued that the tests would pollute the global commons beyond national jurisdiction, this claim was never reached by the Court; presumably the required showing of harm on

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199. *See* Hardy, *supra* note 192 at 299-300; Springer, *supra* note 198.

200. This is true even in situations like the *Trail Smelter* case, in which the damages claimed were damages suffered by private individuals. There, the arbitral tribunal found that the other state was liable since it had an obligation to prevent activities on its own territory that could damage property across the national border. *See* 3 R. Int'l Arb. Awards 1905 (1938 & 1941). *See generally* Springer, *supra* note 198, at 537-38. Similarly, when individuals claim relief for damages suffered outside national territory, the basis of their claim is that as nationals of one state they have been injured by activities impermissibly conducted or authorized by that or another state.

201. *See* text at note 194 *supra.*

202. Nuclear Tests Cases, (Australia v. France), [1973] I.C.J. 99 (New Zealand v. France), [1973] I.C.J. 135 (Interim Protection).

203. [1973] I.C.J. at 106.

204. [1973] I.C.J. at 140.

205. Nuclear Test Cases [1974] I.C.J. at 253, 457. (Judgment).

206. *See* [1974] I.C.J. at 270, 475.

207. *See generally* Goldie, *The Nuclear Tests Cases: Restraints on Environmental Harm,* 5 J. MAR. L. & COM. 491, 500-505 (1974).

this issue, as on the question of interference with high seas freedoms,[208] would be more difficult.

Due to the difficulty of attributing damages resulting from ocean disposal of radioactive waste,[209] the serious and irreversible consequence of potential nuclear pollution from ocean disposal,[210] and the difficulty of establishing substantive international standards based on the multiple and various interests of States in the marine environment,[211] international cooperation on these issues is critical. Developments in international law on transfrontier pollution,[212] shared resources, and international areas support the claim that international cooperation may be required in cases in which harmonization of national policies is essential to effective management of natural resources and protection of the environment.[213] Developments at UNCLOS III also support the claim that there is an obligation for States to cooperate, especially through international organizations, to protect the marine environment against polluting activities subject to their national jurisdiction.[214] With respect to dumping,[215] the Draft LOS Convention provides:

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208. *See* [1973] I.C.J. at 103, 139-40.

209. *See* text at note 191 *supra*.

210. *See* text at note 193 *supra*.

211. *See* text at note 194 *supra*.

212. The OECD Council has been able to adopt several resolutions dealing with transfrontier pollution problems, including principles governing activities and equal right of access to judicial remedies. *See generally* ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, OECD AND THE ENVIRONMENT (Paris, 1976). The basic resolutions are reprinted in 16 INT'L LEGAL MATERIALS 977 (1977), 15 INT'L LEGAL MATERIALS 1218 (1976), and 14 INT'L LEGAL MATERIALS 242 (1975). On procedural responsibilities regarding intergovernmental consultation, see also ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, *Recommendation of the Council for Strengthening International Cooperation and Environmental Protection in Frontier Regions*, OECD Doc. C (78) 77 (Final) (Sept. 27, 1978).

213. *See generally* O. SCHACHTER, SHARING THE WORLD'S RESOURCES 35-83 (1977).

214. *See generally* Draft LOS Convention, *supra* note 26, art. 197 (global and regional cooperation, including cooperation through international organizations, on marine pollution); *id.* art. 204 (duty of states to monitor pollution of the marine environment independently or through international organizations); *id.* art. 207(4)-(5) (international cooperation in international organizations to prevent land-based pollution, including toxic and especially persistent substances); *id.* art. 208(5) (cooperation on continental shelf activities in regional and global organizations); *id.* art. 209 (establishment of international rules for deep seabed mineral activities); *id.* art. 211(1) (international cooperation in international organizations or diplomatic conferences to establish rules for prevention of pollution from vessels); *id.* art. 212(3) (international cooperation, through international organization or conference, to prevent atmospheric transport of pollutants to the oceans). For an analysis of the developing roles of international organizations in this area, *see generally* Kingham & McRae, *Competent International Organizations and the Law of the Sea*, MARINE POL'Y, Apr. 1979, at 106.

215. Dumping is defined as including: "(i) any deliberate disposal of wastes or other mat-

> States, acting especially through competent international organizations or diplomatic conference, shall endeavour to establish global and regional rules, standards and recommended practices and procedures to prevent, reduce, and control pollution of the marine environment by dumping. Such rules, standards and recommended practices and procedures shall be re-examined from time to time as necessary.[216]

The virtually indispensible nature of international cooperation on ocean disposal of radioactive waste, combined with the recent history of its regulation, support the conclusion that an international law of cooperation does exist with respect to such activities. The specific State obligations based on contemporary State practice cannot be understood, however, without an examination of the legal considerations applicable to the classes of activities under consideration.

A. *Discharges into Internal and Territorial Waters*

Nuclear power plants and reprocessing facilities[217] often discharge effluent wastes into rivers or coastal waters. These discharges are primarily subject to national environmental policies which are operative[218] in areas, such as internal waters and the territorial sea, that fall within national sovereignty. A number of resolutions of the United Nations General Assembly[219] and its Charter of Economic Rights and Duties of States[220] stress the sovereign right of States to decide their internal natural resources policies. But this generally conceded[221] right is coupled with the obligation *inter alia* to avoid environmental harms outside the nation's borders. As stated in Principle 21 of the Stockholm Declaration:

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ter from vessels, aircraft, platforms or other man-made structures at sea; (ii) any deliberate disposal of vessels, aircraft, platforms or other man-made structures at sea." Draft LOS Convention, *supra* note 26, art. 1(5)(a). *Compare* London Convention, *supra* note 5, art. III(1).

216. Art. 210(4). *See also* arts. 210, 194(3)(a)(iii).

217. *See* text at notes 28-43 *supra*.

218. *See* Bilder, *supra* note 194, at 453-457.

219. *See generally* Sohn, *supra* note 168, at 485-88.

220. G.A. Res. 3281, 29 U.N. GAOR, Supp. (No. 31) 50, U.N. Doc. A/9631 (1974), art. 2 (principle of permanent sovereignty). *See also id.* art. 30 (state responsible to ensure that internal environmental policies do not damage the environment in transfrontier areas).

221. *See generally* M. RAJAN, SOVEREIGNTY OVER NATURAL RESOURCES (1978).

> States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.[222]

Ocean tides and currents ordinarily will transport discharges from nuclear facilities to areas of the high seas and to the territorial seas and resource zones of other nations.[223] To date, no evidence exists of harm occurring as a result of these inadvertent transfers of waste nor, apparently, have any diplomatic protests been issued concerning such discharges.[224]

The situation with respect to effluent discharges from nuclear facilities is made more complex, however, by the need to summarize all doses to exposed human populations[225] in order to apply the generally recognized ICRP recommendations.[226] ICRP dose limitations must therefore be applied transnationally to doses attributable to nuclear operations.[227] However, since ICRP recommendations also require a justification and optimization of anticipated exposures,[228] international evaluation of proposed acitivites appears necessary as well, in order properly to determine transnational effects. Otherwise activities conducted in one State—for example, commercial nuclear reprocessing—could prejudice decisions of other States to permit radioactive effluent discharges or other forms of radioactive waste disposal or decisions to develop coastal fisheries or other resources over which they have control. Discharges in other States could even affect national decisions about human exposures from other, non-marine, sources of radiation

222. Stockholm Conference Report, *supra* note 168, at 3. *See also* Sohn, *supra* note 168, at 485.

223. *See* note 43 *supra*.

224. *See, e.g.*, Pelzer, *Le caractere admissible au regard du droit international du deversement en mer des dechets radioactifs*, in 2 CAHIERS DU DROIT DE L'ÉNERGIE ATOMIQUE 106 (1969) (noting Irish official silence on coastal discharges in the U.K.).

225. *See* International Commission on Radiological Protection, Implications of Commission Recommendations that doses be kept as low as Readily Achievable, ¶ 17 ICRP Pub. No. 22 (1973).

226. *See* text at notes 38-41 *supra*.

227. *See, e.g.*, ROYAL COMMISSION REPORT, *supra* note 37, at 88.

228. *See* text at note 40 *supra*.

such as medical X-rays. At the very least this situaton suggests that "harmonization" of national policies on discharges would be necessary[229] if significant transboundary effects were expected. Similarly, effluents which reached the high seas or the resource zone of another State could affect the value of the fisheries resources in these areas in such a way that economic and other decisions of the fishing State could be affected. This problem calls for avoidance of pollution of these areas in excess of some internationally agreed standards.

Discharges into internal waters and the territorial sea generally involve similar legal considerations except in two instances:

1. *International Watercourses*

Discharges into internal waters will sometimes occur into international watercourses[230]—water bodies, like river systems and lakes, which are shared by two or more States.[231] In this case, the riparian States have special obligations, including the substantive obligation to achieve an equitable utilization pattern based on historical usage and general notions of equity. In addition, the riparian States have the procedural obligation to consult with other riparians about the effect of certain actions.[232] The U.N. General Assembly has recently requested States to apply the principles for shared resources developed by the United Nations Environment Program,[233] but was unable to adopt them as a code.[234] Neverthe-

229. *See* NEA STUDY, *supra* note 8, at 61.

230. "International watercourse" is the term employed by the United Nations International Law Commission (ILC), which is currently considering drafting an international convention on this subject. *See, e.g.*, Report of the International Law Commission, U.N. GAOR, Supp. (No. 10) 443-47, U.N. Doc. A/34/10 (1979).

231. There is little agreement on what would constitute an international watercourse, specifically on whether the term should include all aspects of shared water resources including ground water. *See generally* Schwebel, *supra* note 16, at 12-17. It would appear that at least significant internationally shared rivers and lakes would be included. *See id.* For marine waters, certain shared water bodies could constitute "enclosed or semi-enclosed seas" for which the littoral states could have special obligations for environmental cooperation. *See* Draft LOS Convention, *supra* note 26, arts. 122-123.

232. *See, e.g.*, Schwebel, *supra* note 16.

233. Draft Principles of Conduct in the Field of the Environment for the Guidance of States in the Conservation and Harmonious Utilization of Natural Resources Shared by Two or More States. The principles have been adopted by UNEP. UNEP Governing Council decision 6/14 of May 19, 1978. U.N. GAOR, Supp. (No. 25) 154-55, U.N. Doc. A/33/25 (1978). The fifteen principles adopted by UNEP are presented, with analysis, in Adede, *United Nations Efforts Toward the Development of an Environmental Code of Conduct for States Concerning Harmonious Utilization of Shared Natural Resources*, 43 ALB. L.

less these principles are widely taken to express the special responsibilities of States sharing resources such as international watercourses.[235] Discharges of radioactive effluents into internal waters which are part of an international watercourse could therefore be subject to a special requirement of international consultation to achieve a mutually agreeable regulatory arrangement.[236]

2. *Applicable International Instruments*

The London Convention as well as most regional agreements on dumping apply within the territorial sea as well as on the high seas.[237] Its definition of regulated dumping could be broad enough to include certain effluent discharges as well as sea dumping of packaged waste since the Convention covers any deliberate disposal of wastes from vessels, aircraft, platforms or other man-made structures at sea.[238] Piped discharges from shore facilities are not subject to the London Convention or most regional agreements.[239] But discharges from floating nuclear facilities[240] could be subject to these internatonal systems of control.[241] Floating nuclear facilities

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REV. 488 (1979).

234. For a description of the debate in the General Assembly and within UNEP itself, see Schwebel, *supra*, note 16, addendum at 9-20.

235. *See* Adede, *supra*, note 233; Schwebel, *supra*, note 16, addendum at 8.

236. Many international agreements have been concluded by states sharing rivers and lakes; some of them specifically provide for control of radioactive pollution. *See, e.g.*, Agreement Between the United States and Canada on Great Lakes Water Quality, art. III, Annex I(1)(h), 23 U.S.T. 301, T.I.A.S. No. 7312, 837 U.N.T.S. 213, (entered into force Apr. 15, 1972) (radiation levels to be kept at lowest practicable levels and in any event controlled to the extent necessary to protect human health); *id.* Annex I(7)(b) (continued consultation to develop "refined objectives" for radioactivity in light of the recommendations of the ICRP).

237. *E.g.*, London Convention, *supra* note 5, art. III(3).

238. *Id.* art. III(1)(a)(i).

239. Piped discharges, even at some distance from the shore, are usually not thought of as ocean dumping. In the United States, for example, such discharges are subject to control as ocean discharges under Sec. 403 of the Federal Water Pollution Control Act Amendments, 33 U.S.C. § 1343 (1972), and not as ocean dumping under 33 U.S.C. § 1412 (1974). *See generally* U.S. Environmental Protection Agency, Ocean Discharge Criteria (final rule) 45 *Fed. Reg.* 65942 (Oct. 3, 1980), *to be codified at* 40 C.F.R. 125. In the United Kingdom, reprocessing discharges have been piped out to sea 2½ km. *See* ROYAL COMMISSION REPORT, *supra* note 37, at 134. Ocean outfalls would not be subject to the London Convention and similar regional conventions since they would not be, *inter alia*, "platforms or other man-made structures at sea," London Convention, *supra* note 5, art. III(1)(a)(i). That this is so is supported by art. VII(1)(c) of the Convention, which obliges parties to apply it *inter alia* only to "fixed or floating platforms under [their] jurisdiction."

240. There is considerable literature on the legal status of such facilities. *See, e.g.*, notes 242-43 *infra*.

241. The applicability of the London Convention and some of the regional conventions is

would most likely be constructed in the territorial sea[242] or possibly outside the territorial sea but within two hundred miles of shore.[243] However, coastal States operating such facilities could claim that their only obligations under applicable conventions are procedural since they have the right to apply their own policies to the natural resources within such zones. The London Convention itself refers to national sovereignty over resources.[244] At this point, coastal States' rights to determine environmental and natural resource policies applicable to domestic activities, including radioactive waste disposal,[245] in zones of extended jurisdiction, are neither clear nor specifically defined.[246]

Thus effluent discharges are not generally subject to any definite system of international control, although discharges into international watercourses may be subject to special requirements and discharges from artificial islands in the territorial sea or on the high seas could be subject to the London Convention and related regional agreements. Considered as land-based sources of pollution of the high seas,[247] however, discharges from shore facilities could be subject to certain embryonic legal requirements. Under the 1974 Paris Convention,[248] for example, several Western European States have committed themselves to take national measures to avoid

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not entirely certain, since it is unclear to what extent effluent discharges from such nuclear plants would be "deliberate disposal" and not normal operations excluded from coverage. *E.g.*, London Convention, *supra* note 5, art. III(1)(b)(i). *See* Courteix, *supra* note 159, at 79.

242. *See, e.g.*, U.S. CONGRESS, OFFICE OF TECHNOLOGY ASSESSMENT, COASTAL EFFECTS OF OFFSHORE ENERGY SYSTEMS 197, 207 (1976) (description of proposed nuclear power plant offshore of the mid-Atlantic states of the U.S.); Herbert & Guieze, *Examen des problèmes juridiques posés par l'implantation des centrales nucléaires sur les îles artificielles*, in DROIT NUCLÉAIRE/OCÉANIQUE-COLLOQUE, *supra* note 47, at 141, 149-52 (legal issues concerning territorial sea location).

243. *See, e.g.*, Albano, *Les installations nucléaires offshore*, in NUCLEAR INTER JURA '75, *supra* note 159, at 99, 104-05 (location within 200-mile zone); Gol, *L'implantation de centrales nucléaires sur des îles artificielles: Le cas belge*, in *id.* at 147, 153-156 (location on continental shelf); von Welck, *Third United Nations Conference on the Law of the Sea and the Use of Nuclear Energy*, 15 NUCLEAR L. BULL. 63, 66-68 (1975) (jurisdictional problems concerning nuclear power plants in an exclusive economic zone).

244. *See* text at note 222 *supra*.

245. *See* von Welck, *supra* note 243, at 69.

246. *See* Schneider, *Something Old, Something New: Some Thoughts On Grotius and the Marine Environment*, 18 VA. J. INT'L L. 147, 151-52 (1977).

247. *See generally* Hickey, *Custom and Land-Based Pollution of the High Seas*, 15 SAN DIEGO L. REV. 409 (1978).

248. Convention for the Prevention of Marine Pollution from Land-Based Sources, Feb. 21, 1974, *reprinted in* 13 INT'L LEGAL MATERIALS 352 (1974) (not in force).

land-based pollution.[249] Similar undertakings exist in other regional agreements, such as the Helsinki Convention[250] and Barcelona Protocol.[251] The International Law Association, a private organizaton, has drafted several provisions on this subject.[252] UNCLOS III has developed an article[253] under which States would be obliged to regulate such land-based sources of pollution.[254] The article requires States to harmonize their policies regionally, and to participate in rule-making by international organizations to control toxic or otherwise harmful substances, especially those which are persistent.[255]

B. *High Seas Dumping of Low Level Waste*

Sea dumping of low level waste has usually occurred in deep ocean areas, although some early dumping also occurred on the continental shelf.[256] Modern operations generally occur in deep ocean areas remote from land.[257] In terms of jurisdiction, such dumping is characterized by the high seas location of the dumping operations, use of the deep seabed as a dumping ground, and the fact that the effects of the activity are first and foremost on the international commons.

As an activity occurring on the high seas and primarily affecting the living resources of the high seas, dumping is subject to the "reasonableness" test derived from Article 2 of the Geneva Convention on the High Seas.[258] Since most dumping takes place in areas relatively distant from land, the seabed used to receive

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249. *See, e.g., id.* art. 4 (national action to eliminate land-based pollution) and art. 5 (adoption of national measures to forestall and, as appropriate, eliminate pollution of the maritime area from land-based sources by certain defined radioactive substances).

250. The Helsinki Convention, *supra* note 177, does not speak of land-based sources specifically, but mandates parties to take appropriate national action to prevent marine pollution of the Baltic. *Id.* art. 3(1). It does not specifically address radioactive substances.

251. *See* note 177 *supra.*

252. International Law Association, Report of the Fifty-Fifth Conference 97-106 (1972). *See generally* Hickey, *supra* note 247, at 471-74.

253. Draft LOS Convention, *supra* note 26, art. 207.

254. *Id.* art. 207(1).

255. *Id.* art. 207(3)-(5).

256. *See* text at notes 56, 64-65 *supra.*

257. *See* text at notes 158 *supra.*

258. *Id. See also* Draft LOS Convention, *supra* note 26, art. 87(2) (exercise of high seas freedoms with "due consideration" to interests of other states in similar freedoms). The claim that sea dumping is a reasonable use of the high seas is made by McDougal and Burke, *supra* note 154, at 852-68. *See also* McDougal & Schlei, *supra* note 153, at 660-61 (reasonableness of atmospheric nuclear tests on remote sea islands).

dumped wastes is usually beyond national jurisdiction. As such the claim could be made that this area is subject to common ownership and control under legal developments associated with UNCLOS III.[259] Therefore, dumping could constitute an impermissible appropriation of the deep seabed preventing mineral exploitation[260] or it could constitute pollution of the deep seabed and its living resources.[261] These claims, based on the common heritage in the deep seabed, could prove attractive politically.[262] It is improbable, however, that dumping would interfere with exploitation of seabed mineral resources.[263] The effect on organisms of the deep seabed would appear to be marginal, both economically and biologically.[264] Much more important legally, therefore, is whether dumping operations are reasonable uses of the high seas. This treatment of the activity is supported by the history of State practice, international agreement, and scholarly commentary; all have approached dumping operations as a use of the high seas. Nevertheless, this history

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259. Draft LOS Convention, *supra* note 26, art. 136 (seabed beyond national jurisdiction "the common heritage of mankind"). Several resolutions of the U.N. General Assembly have declared the seabed beyond national jurisdiction as being in certain respects *res communis*. *See, e.g.*, G.A. Res. 2759, 25 U.N. GAOR, Supp. (No. 28) 24, U.N. Doc. A/8028 (1971) [hereinafter cited as Seabed Principles Resolution]; G.A. Res. 2574D 24 U.N. GAOR, Supp. (No. 30) 11, U.N. Doc. A/7630 (1969) [hereinafter cited as Seabed Moratorium Resolution]. For a summary of the various actions of the General Assembly on this subject, see generally 1 T. KRONMILLER, THE LAWFULNESS OF DEEP SEABED MINING 19-52 (1980).

260. *See* Böhme, *supra* note 9, at 97.

261. There is little doubt that some contamination of the seabed would result from dumping. *See, e.g.*, Bowen & Livingston, *Radionuclide Distributions in Sediment Cores Retrieved from Marine Radioactive Waste Disposals*, in INT'L ATOM. ENERGY AGENCY, IMPACT OF RADIONUCLIDE RELEASES INTO THE MARINE ENVIRONMENT 79 (Int'l Atom. Energy Agency Proc. Ser., Vienna Symp., forthcoming) [hereinafter cited as Vienna Symposium]. Absorption of released wastes by sediments is desirable, in fact, to further isolate the wastes from the marine environment. *See* text at note 342 *infra*. The question, however, is to what extent such contamination would affect other uses of seabed resources; this would appear to be very limited.

262. *See* notes 389-96 *infra* & accompanying text.

263. Both the London Convention, *supra* note 5, Annex III(B)(1), and the IAEA Recommendations, *supra* note 17, ¶ 2.8.4, provide for consideration of potential resource exploitation in choosing dump sites.

264. Due to their distribution and abundance, deep sea organisms would not be likely to be endangered at the population level by waste dumping. Such organisms largely exist on the basis of nutrients provided by other ecosystems and contribute little to life in upper layers of the ocean. *Id.* at 45. *But see* Rice, *Radioactive Waste Disposal and Deep-sea Biology*, 1 OCEANOLOGICAL ACTA 483, 491 (1978). (Disturbance of deep sea sediments by organisms and the movements of larger organisms, including vertical migration, could transmit waste radionuclides. Local populations of deep sea organisms could be severely affected by waste disposal.)

has to date been dominated by a limited number of States. The reasonableness of sea dumping could be approached differently by nations with divergent economic and cultural situations, including patterns of livelihood and dietary preferences,[265] and by those with less stake in nuclear power.[266]

Regardless of the reasonableness of dumping as a high seas activity when properly conducted,[267] disputes about the reasonableness of specific operations can still occur. Portuguese officials, for example, have voiced uneasiness with current operations conducted at Northeast Atlantic Dump Site[268] and have stressed the need for increased monitoring efforts.[269] But prior to the recent announcement by Japan that it plans to commence dumping, there has been only one formal international protest over a radioactive waste dumping operation—by Mexico against an operation in the Gulf of Mexico which the United States Atomic Energy Commission proposed to license. A representative of Mexico attended the proceedings on the application and the AEC ultimately denied permission to sea dump the wastes.[270]

The reasonableness of high seas dumping depends not only on the circumstances of particular operations but also on the extent to which the applicable scientific issues have been identified and resolved.[271] Due to the presence of long-lived radionuclides in dumped wastes, the consequences of proposed dumping must be viewed cumulatively.[272] The effects of dumping operations conducted by several nations in an ocean basin[273] must be considered

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265. *See* note 41 *supra*.

266. *See* text at note 432 *infra*.

267. *See* M. McDOUGAL & W. BURKE, *supra* note 154, at 863.

268. *See* IMCO, Third Consultative Meeting of the Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, Oct. 9-13, 1978, Report of the Third Consultative Meeting, IMCO Doc. LDC III/12 (Oct. 24, 1978), [hereinafter cited as LDC III report], Annex 9, ¶ 3, *reprinted in* 18 INT'L LEGAL MATERIALS 817, 852 (1979).

269. *See* de Bettencourt, *Contribution au contrôle radiologique du milieu marin*, in NEA Tokyo Seminar, *supra* note 41, at 47.

270. This case, involving licensing of a dumping operation of the Industrial Waste Disposal Corporation, is described in Lowenstein, *Some Legal Considerations in the Ocean Disposal of Radioactive Wastes*, in 6 HEALTH PHYSICS (X. Morgan ed. 1961).

271. *See* M. McDOUGAL & W. BURKE, *supra* note 154, at 852.

272. *See* IAEA Definition and Recommendations, *supra* note 17, Annex at ¶ 2.3.3.5.

273. An ocean basis has been defined by the IAEA for the North Atlantic as constituting 10^{17} m^3 of water. *Id.*, ¶ B.1.2. Models of interregional transport within this large basin have subsequently been developed. *See, e.g.*, Clark & Webb, *A Model to Assess Exposures from Releases of Radioactivity into the Seas of Northern Europe*, in Vienna Symposium, *supra*

in the aggregate[274] to determine if dumping constitutes impermissible pollution of the high seas either by interfering with other uses of the high seas such as fishing (either directly through its effect on populations of marine organisms or more likely by resulting restrictions on human intake of fish products) or by causing pollution of coastal waters.[275] Specifically, the contributions of waste dumping to human exposures under ICRP dose limit guidelines must be calculated on an international basis;[276] therefore, waste dumping policies formulated consistently with ICRP recommendations should also be determined internationally.[277]

An obligation to cooperate in resolution of the scientific and administrative issues would thus appear to be a consequence of the distinctive features of sea dumping and the obligation of States to ensure that such activities are reasonable in the circumstances.[278] To say that there is a customary law of cooperation, *i.e.*, international procedural obligations, in this case does not resolve questions as to the specifics of such procedural requirements. Dumping of radioactive waste has been subject to several international arrangements since such cooperation was encouraged by UNCLOS I in 1958;[279] the process of international cooperation has been progressive and new issues have emerged as agreement has grown on certain aspects of dumping. A review of the most important current issues concerning dumping operations and their procedural context follows.

1. *Environmental Assessment*

Under the London Convention, special permits may be issued[280] for the dumping of low level radioactive wastes,[281] but only "after careful consideration of all the factors set forth in Annex III" of the Convention, "including prior studies of the characteristics of

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note 261, at 6.

274. *See* IAEA Definition and Recommendations, *supra* note 17, at ¶ B.3.1.

275. *See, e.g.*, de Bettencourt, *supra* note 269.

276. *See* text at note 227 *supra*.

277. *See* text at note 229 *supra.* IAEA Recommendations on low level waste dumping call for application of the ICRP recommendations. IAEA Definition and Recommendations, *supra* note 17, ¶ B.1.2.

278. *See* M. McDOUGAL & W. BURKE, *supra* note 154 (reasonableness of high seas dumping dependent on resolution of scientific issues).

279. *See* text at notes 66-79 *supra*.

280. London Convention, *supra* note 5, art. IV(1)(b).

281. *Id.* Annex II(D).

the dumping site"[282] in relation to the satisfactoriness of the site itself or the effects of its use.[283] Such consideration may not actually be required in each case since Annex III itself provides only that the factors included in it are to be considered in establishing criteria for permit issuance.[284] Parties are, however, required to provide notification of all operations[285]—including the circumstances of the operation,[286] results of monitoring,[287] and any additional measures they have adopted.[288]

The recommendations of the IAEA on the issuance of permits for dumping of radioactive waste, which London Convention parties are to take full account of in issuing permits,[289] calls for a "detailed environmental . . . assessment" of the consequences of issuing special permits.[290] The assessment must include an examination of the alternatives to the proposed operation; factors significantly affecting the transport of waste nuclides, including geological and physical oceanographic characteristics at the dump site; dose commitments to humans; and the resulting risk to marine ecosystems.[291] The IAEA interprets these recommendations to mean that appropriate studies should be made of dump sites but that detailed field and experimental studies would not be necessary in each case. The IAEA believes, however, that notifications of permits issued should include this environmental assessment for

282. *Id.* art. IV(2).

283. *Id.* art. IV(2) and Annex III(B), (C). *See also* art. VI(3).

284. In a recent case, it was held that the Administrator of the EPA could authorize continued use of historical dump sites on an interim basis without a full environmental assessment of the consequences of using each site. National Wildlife Fed. v. Costle, 629 F.2d 118 (D.C. Cir. 1980). In reaching this conclusion, the court examined the provisions of the London Convention and domestic law, which required that the Administrator, in establishing *criteria* for dumping, apply the standards and criteria under the Convention, and concluded: "This amendment merely requires application of the Convention standards and criteria by the Administrator in establishing or revising criteria. It does not by its terms apply to either the application of criteria to permit applications or the designation of dumping sites." *Id.* at 1686. In another recent case, a district court *inter alia* upheld use of a "bioassay" testing procedure in applying the EPA criteria but required that the Corps of Engineers, which authorized continuing dumping operations for dredged spoil at an EPA-designated dump site, prepare a programmatic environmental impact statement on such operations at the site. National Wildlife Fed. v. Benn, 491 F. Supp. 1234 (S.D.N.Y. 1980).

285. London Convention, *supra* note 5, art. VI(4).

286. *Id.* art. VI(1)(c), (4).

287. *Id.* art. VI(1)(d), (4).

288. *Id.* art. VI(3), (4).

289. London Convention, *supra* note 5, Annex II(D).

290. IAEA Definition and Recommendations, *supra* note 17, at ¶ .1.1.

291. *Id.* ¶ B.1.4., Annex ¶ 2.4.2.

each application for a special permit.[292]

The extent to which environmental assessments are to accompany notifications have become an issue in formal consultations of the parties to the London Convention. The United States has proposed that the parties implement this recommendation of the IAEA.[293] The United Kingdom[294] and the Netherlands[295] have opposed its adoption. The discussion has centered around the comparative utility of providing environmental assessments on specific operations versus proceeding to designate and evaluate dump sites.[296] Further complications arise because site administration has heretofore been performed by the NEA. Whether the NEA can fulfill the role of a regional organization, as required by the London Convention, is not at all certain.[297]

2. *Dump Site Administration*

As the quantity of radioactive waste dumped at sea increases, proper site selection and monitoring assume greater importance in protecting man and marine resources.[298] Studies of radioactive waste dump sites are required by the London Convention[299] and the recommendations of the IAEA.[300] Due to its organizational role in conducting dumping operations, however, the NEA has been the chief forum for discussion of what studies are required for designation of a dump site and its continued use.

Reviews of the current NEA dumpsite and its use have been conducted by NEA expert groups in 1978 and 1979. Considerable

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292. IAEA Definition and Recommendations, *supra* note 17, ¶ B.1 and Annex, ¶ 2.6.2.

293. *See* LDC-V Report, *supra* note 5, at ¶ 6.6.

294. *Id.* ¶ 6.7.

295. *Id.* ¶ 6.8.

296. *Id.* ¶ 6.8, 6.9.

297. *Id.* ¶ 6.8. Article VIII of the London Convention calls for regional agreements, based on characteristic regional features, to supplement the London Convention framework. Commentators have generally assumed that the NEA is such a regional organization. *See, e.g.*, Reyners, *supra* note 119, at 114. But the NEA, based on purely geographical considerations, is not a regional organization: it is open only to OECD members and includes members outside the European and even North Atlantic areas—*i.e.*, Australia, Japan and New Zealand. Questions have been raised in consultative meetings of the London Convention parties as to whether the objectives of the NEA are fully consonant with those of the London Convention, which was adopted to prevent marine pollution from waste dumping. *See* LDC-V report, *supra* note 5.

298. *See, e.g.*, OECD, NEA, *supra* note 132A, at 39 (site review).

299. London Convention, *supra* note 5, art. IV(2) Annex III(B)-(C).

300. IAEA Definition and Recommendations, *supra* note 17, at ¶¶ B.1.4(3), B.2.1(2), C.2.1.

disagreement has permeated these meetings.[301] The 1978 meeting concluded that the site could be used only for one additional year,[302] and the 1979 meeting concluded that the site could be used for five additional years but that a site-specific scientific program should be developed in 1980 and implemented in 1982.[303] The United States has taken the position that continued use of the site should be conditional upon the timely development and implementation of these site plans.[304] NEA experts have drafted a plan,[305] but actual research and analytic responsibilities remain unclear.[306]

3. *Waste Transport Modelling*

Aside from the need to assess specific operations and utilize a proper dump site, the monitoring of low level waste dumping requires the development of models which estimate the transport of wastes from sites to man and significant living marine resources. Such models allow the establishment of ceilings for total dumping,[307] the effects of which would not exceed ICRP dose limitations for critically exposed populations.[308] Within such ceilings the optimization analysis provided for in the ICRP recommendations should be applied,[309] ideally on an international basis.[310] But in no

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301. *See* U.S. Department of State, Summary, Committee on Ocean Dumping, U.S. Environmental Protection Agency (June 12, 1980) [hereinafter cited as U.S. State Dep't NEA Meeting Summary].

302. *See* Organization for Economic Cooperation and Development, Nuclear Energy Agency, *Seventh Activity Report 1978* 34 (1979).

303. *See* note 81 *supra. See* Organization for Economic Cooperation and Development, Nuclear Energy Agency, *Eighth Activity Report 1979* 35-36 (1980); U.S. State Dep't NEA Meeting Summary, *supra* note 301, at 6-7.

304. U.S. State Dep't NEA Meeting Summary, *supra* note 400, at 6-7. *See also* LDC-V report, *supra* note 5, at ¶ 6.3.

305. *See* Nuclear Energy Agency, *Research and Environmental Surveillance Programme-Plan Relevant to the North-East Atlantic Dump Site* (Draft) (n.d.) [hereinafter cited as *NEA Draft Site Monitoring Plan*]. The IAEA has also convened experts to devise a detailed but generic plan for site selection and monitoring. No official report resulted from this meeting, which was held in Jamaica in 1979, but the conclusions of one of the subgroups has been published by two of its authors as a scholarly article on the subject. This article lays out a very convincing description of the prerequisites of proper selection, maintenance, and monitoring of a dump site for radioactive waste. *See* Bowen & Hollister, *supra* note 263.

306. *See NEA Draft Site Monitoring Plan, supra* note 305. The NEA itself has been unwilling to assume responsibility for actual oceanographic studies related to the dump site. *See* U.S. State Dep't NEA Meeting Summary, *supra* note 301, at 7.

307. *See* IAEA Definition and Recommendations, *supra* note 17, Annex at ¶ 2.3.3.8.

308. *See id.* at ¶ 2.3.4.2.

309. *Id.* ¶ B.1.2. and Annex ¶¶ 2.1.4. & 2.3.4.5.

310. *See* text at notes 227-29 *supra.*

instance should such ceilings on exposures from all sources be exceeded.[311]

The IAEA has twice adopted such models to define high level waste unsuitable for dumping at sea and to establish limitations on the dumping of low level waste. The IAEA's 1975 conclusions were based on[312] an oceanographic model proposed by Webb and Morley in 1973.[313] The IAEA was asked to reconsider the oceanographic model underlying its 1975 work by the parties to the London Convention.[314] In 1978 it revised its definition of high level waste[315] and established limiting rates for total radioactivity dumped.[316] The oceanographic basis of this revision was a three-dimensional physical transport model developed by Shepherd in 1976.[317] The Shepherd model is more restrictive than the Webb and Morley model for radionuclides with half-lives over 3000 years.[318]

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311. *See* IAEA Definition and Recommendations, *supra* note 64, ¶ B.1.2.

312. IAEA Provisional Definition and Recommendations, *supra* note 109, Annex ¶ 2.3.2 & n.1.

313. National Radiological Protection Board, *A Model for the Evaluation of the Deep Ocean Disposal of Radioactive Waste* 1 (No. NRPB-R14, 1973). This model was essentially a two-dimensional vertical diffusion model intended to yield estimates of the concentrations of waste nuclides in the surface waters above a hypothetical dump site. Linear diffusion across a barrier separating deep and shallow waters was assumed; this barrier, although generic, resembled what was thought to occur in the Northeast Atlantic due to the pycnocline (salinity gradient) caused by the inflow of Mediterranean water. Although this model is unrealistic since it does not account for the important effects of horizontal advection (transport by currents) in the deep ocean, it may be satisfactory for short-lived components of dumped waste. *See* Webb & Grimwood, *A Revised Oceanographic Model to Calculate the Limiting Capacity of the Ocean to Accept Radioactive Waste,* (Nat'l Radiological Protection Bd., No. NRPB-R 58, 1976). The presence of long-lived radionuclides, however, makes it necessary to consider concentrations in a wider area. *See, e.g.*, Miyake & Saruhashi, *A Critical Study of the IAEA Definition of High Level Radioactive Waste Unsuitable for Dumping at Sea,* 27 PAPERS IN METEOROLOGY AND GEOPHYSICS 79 (1976).

314. *See* Intergovernmental Maritime Consultative Organization, First Consultative Meeting of Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, Sept. 20-24, 1976, Report of the First Consultative Meeting, IMCO Doc. LDC-I/16, at 15 (1976) [hereinafter cited as LDC-I report].

315. IAEA Definition and Recommendations, *supra* note 17, at ¶ A.1.1.

316. *Id.* ¶ B.1.2.

317. Sheperd, *A Simple Model for the Dispersion of Radioactive Wastes Dumped on the Deep-Sea Bed,* in FISHERIES RESEARCH TECHNICAL REPORT No. 29 (1976) (U.K. Ministry of Agriculture, Fisheries, and Food, 1976).

318. *Id.* at 14. This model essentially allows for horizontal transport by advection throughout the bottom water of an idealized ocean basin, which is also subject on an overall basis to vertical diffusion. A safety factor of ten is included to account for possible vertical advection by upwelling, but it was contended that the effect of removal of radionuclides from the water column by sedimentation or vertical isolation by a pycnocline would proba-

The choice of physical transport model presents only one of the complicated problems arising from the need to estimate the impacts of dumping. Another problem concerns the need to determine the potential impact on humans. Radiological exposure to humans is estimated based on selected pathways, some involving direct exposure and others ingestion of marine products.[319] Estimations of doses received by man from consuming marine life, as well as the dose commitments of the marine organisms themselves, are determined by looking at so-called concentration factors. The relevant concentration factor for each marine species is a constant factor derived from the relationship of the concentrations of various radionuclides in its tissues to those in the surrounding water.[320] These factors are not intended to give a completely realistic model of the uptake of radioactivity by marine organisms, but rather are established so as to be deliberate overestimations.[321] It is widely recognized, however, that certain means of biological transport could lead to accumulation of radionuclides in excess of those expected by this method,[322] especially as the result of site specific factors.[323] However, biological action probably generally removes

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bly offset any such vertical transport. The result of application of this model is that the nuclide concentration in the surface layer would be less than the average concentration in the entire basin if it were well mixed. *Id.* The IAEA has in adopting this model modified it by adding the assumption of a concentrated plume of released activity for short or intermediate-lived but very active substances. IAEA Definition and Recommendations, *supra* note 17, Annex ¶¶ 2.3.3.1-.3. The IAEA also based its estimates of available radionuclides on their concentrations in the bottom water as calculated according to Shepherd but assuming a very slow vertical diffusion. *See* Van As & Forster, *Disposal of Radionuclides in the Sea*, IAEA BULL., Aug. 1973, at 24, 27. The IAEA assumed a slow vertical diffusion, resulting in greater estimated bottom concentrations, in order to account for possible direct transmission of bottom concentrations to the surface through biological pathways. IAEA Definition and Recommendations, *supra* note 17, Annex at 2.33.4.

319. *Id.*, Annex at ¶ 2.3.4.1. *See* International Atomic Energy Agency, *The Radiological Basis of the IAEA Revised Definition and Recommendations Concerning High-Level Radioactive Waste Unsuitable for Dumping at Sea*, IAEA Doc. IAEA-211 at 10-17 (1978) [hereinafter cited as IAEA Radiological Consultants' Report].

320. *Id.* at 12-13.

321. *See* Webb, *The Interaction Between Radiological Assessments and Research Requirements Related to Waste Disposal in the Deep Sea*, in NEA Tokyo Seminar, *supra* note 41, at 16; *id.* at 398-99 (comments of Mr. Webb).

322. *See id.* at 396 (comments of Messrs. Webb and Pentreath). *See also* ROYAL COMMISSION REPORT, *supra* note 37, at 142 (reconcentration of plutonium from wastes much higher than from fallout; physical transport of wastes to fishing grounds could lead to accumulation in the food chain).

323. The potential importance of biological transmission at dump sites was recognized by the IAEA in its oceanographic model. *See* IAEA Definition and Recommendations, *supra* note 17, Annex at ¶ 2.3.3.4. One example is the existence of a long-line fishery for the black

more radionuclides from the water column through defecation and sedimentation than are concentrated through biological pathways.[324] The IAEA will continue to evaluate the suitability of the oceanographic and radiological models used in establishing limitations on waste dumping which are based on estimates of likely human exposure.[325]

4. *General Strategy*

As a result of proceedings under the London Convention, in the IAEA, and in the NEA, a general strategy has begun to emerge for future sea dumping. In its provisional Definition and Recommendations,[326] the IAEA defined high level waste in terms of the concentrations of types of radionuclides per unit of mass[327] and established only general guidelines on low level waste dumping[328] without numerical limitation of total releases from dumped wastes. London Convention parties then requested consideration of a "strategy of dilution and dispersion implicit in the Provisional Definition."[329] In its revised Definition and Recommendations, the IAEA responded by adopting numerical limitations for yearly releases of radionuclides into an ocean basin and stated:

> It is essential that a general policy of continued isolation and containment of radioactive waste after descent to the sea-bed should be pursued through the use of suitable packaging to minimize to the extent reasonably achievable the radioactivity which might ultimately be released, thereby preventing unnecessary contamination of the marine environment.[330]

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scabbard fish near the Northeast Atlantic dump site. *See NEA Draft Site Monitoring Plan, supra* note 305, at 8.

324. *See, e.g.*, Webb, in NEA Tokyo Seminar, *supra* note 41, at 15-18. Some scientists, however, are critical of the primary reliance on mathematical models based on physical transport and stress the potential importance of biological transmission. *See, e.g.*, Rice, *supra* note 264, at 484.

325. GESAMP has recently agreed to assist the IAEA in this regard. *See* Intergovernmental Maritime Consultative Organization, Fifth Consultative Meeting, Relations with other Organizations, Note by the Secretariat, IMCO Doc. LDC-V/9 (July 8, 1980), at 2.

326. *See* IAEA Definition and Recommendations, *supra* note 17.

327. *Id.* at ¶ A.1.1.

328. *Id.* at ¶ B.

329. *See generally id.* at ¶ B.1.3.

330. *Id.* at ¶¶ B.1.2.(a)-(c), B.1.2.3 (no permit should be given which would cause these limits to be approached).

Waste dumping cannot be considered a true isolation stragegy, since the containment of wastes is expected to only partially succeed and waste nuclides are expected to become dispersed in the ocean which dilutes their concentrations to safe levels. Greater isolation and containment can be achieved, however. Improved packaging is one way; guidelines on waste packaging have been issued by the NEA[331] and the IAEA is preparing a report on waste packaging.[332] Restriction of dump sites to deep ocean areas (4000 meters) and avoidance of high latitudes (50° North and South),[333] as required under IAEA recommendations also demonstrate development of a qualified isolation strategy for dumped wastes, since these areas may be characterized by high biological productivity.[334]

To date, the masses of weight dumped per year have never exceeded ten percent of the mass per rate site assumed by the IAEA. Total amounts of radionuclides dumped have never exceeded one percent of the upper limits on releases into an ocean basin, and for some nuclides have been much lower.[335] Thus far, however, the work of the IAEA has been general in nature, focusing on upper limits on waste concentration[336] or release[337] and establishing only overall guidelines on dumping policy[338] and operations.[339] Continued pursuit of an isolation strategy will require more attention to selection, operation, and monitoring of specific dump sites. Such sites should be strictly limited in number and size.[340] Properly chosen dump sites can reduce the likelihood of biological transmission of waste substances,[341] improve isolation by allowing wastes released from their containment to become incorporated into sedi-

331. See the decisions of the OECD Council, Nuclear Energy Agency, Guidelines for Sea Dumping Packages of Radioactive Waste (July 22, 1977, rev. Apr., 1979).

332. *See* International Atomic Energy Agency, Draft Report on Packaging of Radioactive Wastes for Sea Disposal (July, 1980), *reprinted in* IAEA Definition and Recommendations, *supra* note 17, app. 2.

333. *Id.* at ¶ C.2.1(2).

334. *See* Bowen & Hollister, *supra* note 263, at 18, para. 6.

335. *See* IAEA Definition and Recommendations, *supra* note 17, at Annex 2.2.2. (annual amounts have only twice approached even 10% of the upper limit).

336. *See generally id.* at ¶ A.1.1.

337. *Id.* at ¶ B.1.2. *See also* ¶ A.2., n.1 (bases the definition on calculated upper limits to activity release rates from all sources, other than natural sources, for purposes of defining high level wastes).

338. *See id.* at ¶ B.

339. *See id.* at ¶ C.

340. *See id.* at ¶¶ C.2.1(6), C.2.2.

341. *See, e.g.*, de Bettancourt *et al.*, *supra* note 269 (advocates site specific studies of biological transmission at the Northeast Atlantic site).

ments[342] and prevent waste substances from being rapidly transported by bottom currents.[343] Furthermore, the proper choice of a dump site will enhance the opportunities for the study and monitoring of waste transmission.[344] It is difficult to say whether or to what extent there is a sufficient consensus in the scientific community that such improvements in the isolation of dumped wastes are necessary to make the claim that they are legally required as a condition of the reasonableness of continued operations. There is considerable disagreement among the NEA participants about the need to improve administration at the current dump site.[345]

Assuming that proper international controls are applied, however, there is reason to believe that sea dumping could be a safe method of low level waste disposal.[346] Some improvements to the current system of control can be imagined—for example, a complete register of dumped waste maintained by international organizations.[347] But it is important to realize that for some nations sea disposal is an extremely attractive method of low level waste disposal due to inadequate disposal areas on land.[348] If such countries are pressured into certain refinements in the isolation of wastes, such as improved packaging, then they may respond by using these improvements to justify an expansion of their dumping activity.[349] Additional pressure on countries practicing dumping could also lead to use of sites within two hundred miles of shore, probably with improved containment.[350] This could happen especially if Third World countries, which currently have less of a stake in nuclear power, begin to challenge continued use of the high seas and seabed beyond national jurisdiction for dumping. If countries practicing dumping move within their extended resource zones, it could be difficult to control or challenge their practices.

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342. *See* Bowen & Hollister, *supra* note 263, at 19 (high organic, low ion-exchange sediment is least suitable for dumping).

343. *See id.* at 6.

344. *See generally id.* at 21-23 (site monitoribility).

345. *Seed* text at notes 400-06 *supra.*

346. *See, e.g.*, NEA STUDY, *supra* note 130 at 48-50.

347. *See* LDC-V Report, *supra* note 5, at 12-13, ¶ 6.6 (U.S. support for compilation of international register). Such a register was proposed in the Brymielsson Report in 1960. *See* text at notes 250-52 *supra.*

348. *See, e.g.*, du Pontavice, *supra* note 251, at 727.

349. *See* Webb in NEA Tokyo Seminar, *supra* note 52, at 17.

350. *See* NEA Tokyo Seminar, *supra* not 52, at 398, (comments of Mr. Pentreath).

C. *Ocean Disposal of High Level Waste*

Ocean disposal of high level waste would most likely occur through seafloor or seabed emplacement. Other possible methods include disposal on natural islands, drilled insertion into continental shelf geological formations from platforms or artificially constructed islands, and engineered emplacement on or in the continental shelf. In theory, natural islands and their immediately surrounding waters are subject to full State sovereignty,[351] although in certain cases such islands may not have a continental shelf or exclusive economic zone.[352] State sovereignty over islands means that for the most part activities on islands are not governed by law of the sea principles and enforceable international agreements on marine pollution such as the London Convention are generally not applicable.[353] Using the land mass of islands as a medium for high level waste disposal would intentionally expose the marine environment to certain risks; the location of repositories on islands would also necessarily involve some maritime transportation of wastes.[354] Choice of an island repository represents a deliberate decision to use the ocean either as a medium of disposal or at least as a "buffer" in case of an unanticipated release of wastes from the primary disposal medium.[355]

International environmental law is poorly equipped to deal with situations in which national actions create a risk to the global commons or other transfrontier areas. Marine pollution is currently defined as "the introduction by man, directly or indirectly, of substances or energy into the marine environment . . . which results or is likely to result in" certain injuries,[356] requiring that a release of pollutants occur and not only a risk of their release. For certain "ultra-hazardous"[357] activities such as nuclear plant operations[358]

351. *See* Draft LOS Convention, *supra* note 26, art. 121(1)-(2) (regime of islands).
352. *See id.* art. 121(3).
353. London Convention, *supra* note 5, art. III(1)(a).
354. *See* DOE GENERIC EIS, *supra* note 20, at 6.52.
355. *See id.* at 6.59.
356. Draft LOS Convention, *supra* note 26, art. 1(4).
357. *See generally* Jenks, *Liability for ultra-hazardous activities in international law* [1966] I Rec. des Cours (Neth.) 105; Kelsen, *State Responsibility and the Abnormally Dangerous Activity,* 13 HARV. INT'L L.J. 197 (1972).
358. *See generally* Handl, *An International Legal Perspective on the Conduct of Abnormally Dangerous Activities in Frontier Areas: The Case of Nuclear Power Plant Siting,* 7 ECOLOGY L.Q. 1 (1978).

and radioactive waste disposal[359] a customary law of international cooperation to reduce the risks of pollution appears to be developing. The substantive legal norms in this area are those generally accepted in the world community as a result of intergovernmental cooperation and activities of international organizations. Violations of these norms could represent a serious breach of international law. Since the state of the law regarding a particular activity may not be clear at the outset, a State may be obliged to consult with other States directly or through international organizations before proceeding. Even if creation of a risk did not violate a substantive legal standard, a State could still be responsible for any consequences.[360] However, since State liability would probably not be an effective remedy if the risked consequences occurred, other States could be expected to take political action to prevent such activities from being conducted if they were not satisfactorily consulted.

The fact that the risks of ocean disposal of high level waste are essentially global means that legal immunities based on jurisdictional considerations are likely to be unavailing. For example, engineered or drilled repositories on or in the continental shelf, like islands, would be primarily subject to national jurisdiction.[361] But like island sites, such repositories would be chosen for their oceanic location[362] and would also involve maritime transport of wastes. Such repositories would not be related to the natural resources of the continental shelf, which has historically been the basis for State jurisdiction over activities on the shelf.[363] In addition, continental shelf repositories would most likely be constructed within

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359. *See, e.g.*, NEA STUDY, *supra* note 8, at 61.

360. The United Nations International Law Commission has taken up as a subject "international liability for injurious consequences arising out of acts not prohibited by international law." For preliminary reports on this subject, see U.N. Docs. A/CN.4/334 (June 24, 1980), Add. 1 (June 27, 1980), and Add. 2 (July 4, 1980) (preliminary report by Mr. Quentin-Baxter, Special Rapporteur).

361. *See* Draft LOS Convention, *supra* note 26, art. 80 (exclusive right of coastal state over all artificial islands, installations, and structures on the continental shelf).

362. *See* text at notes 150-51 *supra*.

363. *See* Geneva Convention on the Continental Shelf, art. 2(1), *done* April 29, 1958, 15 U.S.T. 471, T.I.A.S. No. 5578, 499 U.N.T.S. 311, *entered into force* June 10, 1964. *See also* Draft LOS Convention, *supra* note 26, art. 77. *Cf.* United States v. Alexander, 602 F.2d 1228 (5th Cir. 1979) (U.S. has jurisdiction over all the natural resources of its continental shelf under the Geneva Convention but the Department of Interior exceeded its authority under the Outer Continental Shelf Lands Act (OCSLA) to promulgate regulations forbidding taking or damaging coral, since the OCSLA was enacted only to regulate activities involved in developing the oil and gas resources of the continental shelf).

two hundred miles of shore in order to increase assurance of national jurisdiction.[364] But neither use of the shelf nor location within a marine resource zone detracts from the fact that the intent of emplacing such repositories is to take advantage of the dispersal characteristics of the ocean in case a release of waste were to occur.

Seafloor emplacement, which likewise would involve an attempt to contain the waste for a considerable length of time, would also place secondary reliance on the ocean as a medium of dispersion and dilution if unplanned releases occur and after the ultimate failure of containment. Unless political pressures caused a move to deep ocean areas within two hundred miles of shore, seafloor emplacement would probably occur on the deep seabed beyond national jurisdiction in order to take advantage of the remoteness and unproductivity of mid-ocean areas.[365] Because of the briefer time of effective containment, wastes so disposed could be further processed (partitioned) to reduce their radiological hazard.[366] It has been argued that a seafloor emplacement system would have the desirable properties of easy monitorability and ready retrievability.[367]

The London Convention now prohibits the sea dumping of high level waste.[368] Nothing in the Convention or the regulations of the IAEA exempts the disposal of otherwise blacklisted wastes if they are effectively contained.[369] But seafloor emplacement could be legitimized under the London Convention framework in several ways, including amendment of the annexes to the Convention, adoption of a special protocol, or further rulemaking by the IAEA. For example, special regulations were adopted by the London Convention parties for the new technology of incineration of certain Annex I substances on board specially equipped vessels at sea,

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364. *See* text at notes 242-45 *supra*.

365. *See* text at note 137 *supra*.

366. *See* Nielsen, *Comparison of Some Geological and Ocean Disposal Concepts Regarding Realistic Modeling That Allows Objective Risk Assessment to be Made*, in 1 SCIENTIFIC BASIS FOR NUCLEAR WASTE MANAGEMENT 549, 553 (G. McCarthy ed. 1978).

367. *See* text at notes 139-41 *supra*.

368. *See* London Convention *supra* note 5, art. IV(1)(a) & Annex 1(6).

369. An official English source has commented, however, that seafloor emplacement might be considered outside the London Convention definition of "dumping" if the containment prevented wastes from leaking into the ocean beyond a certain threshold. *See* ROYAL COMMISSION REPORT, *supra* note 37, at 150. This argument is similar to one sometimes made for seabed emplacement. *See* text at notes 372-82 *infra*.

which was shown to lead to virtually complete destruction of these substances.[370] The parties amended the annexes of the Convention and adopted a special set of regulations and technical guidelines[371] to control this practice. New containment methods for seafloor emplacement of high level radioactive waste could be treated similarly.

Further development of the IAEA Definition and Recommendations[372] might also make seafloor emplacement permissible. Currently, the IAEA definition of "high level waste unsuitable for disposal at sea" is formulated in terms of concentrations of various waste nuclides over an assumed upper limit on the mass so disposed.[373] The IAEA has stated that "to meet the objectives of the Convention it is necessary to express the [d]efinition (of high level waste) in terms of a concentration (radioactivity per unit mass)."[374] The IAEA recognizes that "the initial concentration at the source is unlikely to be important to determining the hazard to man,"[375] and that only release rates are important in terms of radiological consequences.[376] Nevertheless the Convention specifically calls for

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370. *But see* U.S. DEPARTMENT OF STATE, U.S. ENVIRONMENTAL PROTECTION AGENCY, FINAL ENVIRONMENTAL IMPACT STATEMENT ON THE INCINERATION OF WASTES AT SEA UNDER THE 1972 OCEAN DUMPING CONVENTION, CH. VII (FEB. 1979).

371. Paragraph 10 was added to Annex I to the effect that the prohibitions on organohalogen compounds and oils would not apply to disposal by incineration at sea, and that parties should issue special permits for such activities, applying the regulations, and taking full account of the technical guidelines. An amendment to Annex II applied similar requirements to incineration of Annex II substances. London Convention, *supra* note 5, Annex I, Addendum (Regulations for the Control of Incineration of Wastes and Other Matter at Sea); *id.* Annex II.

372. The Radiological Basis of the IAEA Revised Definition and Recommendation Conceriing High-Level Radioactive Waste Unsuitable for Dumping at Sea, Report of Consultants of International Atomic Energy Agency, IAEA Doc. 211 (June 13-17, 1977).

373. *See* IAEA Definition and Recommendations, *supra* note 17, at ¶ A.1.1 & n.1. These concentrations were calculated from limits on release rates derived through application of the IAEA oceanographic and radiological models, on the assumption that all waste disposed would be released immediately. *Id. See, e.g.,* Annex ¶¶ 2.3.4.5. & 2.3.7.; Nielsen, *supra* note 359, at 553. But it may also be possible to model releases from containment so that release rates could be used directly to define high level waste; this calculation could be accompanied by a restriction on total waste nuclides disposed per site, or in the ocean generally, to account for a possible catastrophic failure of containment. *Id.* at 552. Nielsen imposes this limitation per site based on the possibility of "maximum accident" or the release of all radionuclides from the repository site over a brief period shortly after disposal.

374. IAEA Definition and Recommendations, *supra* note 17, Annex at ¶ 2.3.7.

375. *Id.* Annex at ¶ 2.3.3.8.

376. *See* IAEA Radiological Consultants Report *supra* note 319, at 28. The consultants concluded,

> 2. The initial concentrations of radioactivity in wastes dumped into the deep

a definition of high level waste.[377]

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oceans are unlikely to be important in determining the subsequent hazards to man, although the total radioactivity in a canister may need to be limited for operational reasons.

3. The hazards to man and the ecosystem are largely determined by the rates of release of radioactivity to the oceans and it is these which should be controlled. We have not been able to establish on radiological grounds any upper limit to the initial concentration of radioactivity in wastes destined for deep ocean disposal.

4. We conclude therefore that there are no high level wastes that are intrinsically unsuitable for dumping at sea but that quantities dumped should be strictly controlled on the basis of release rate limits.

5. The rates of release of radioactivity to the oceans can be reduced by suitable containment and packaging of wastes. When it has been established that wastes can be contained for a given length of time, an allowance for decay in situ, relative to that time [sic] may be considered. . . .

377. *See* London Convention, *supra* note 5, Annex I(a). The United States has consistently sought a qualitative definition that would make it clear that high level reprocessing wastes and spent fuel are prohibited from dumping. *See, e.g.*, 1980 *Hearings, supra* note 1, at 252-53 (statement of Leslie H. Brown). Although the IAEA definition does not currently contain a qualitative standard, the IAEA has commented: "The Definition also covers those wastes which *have relatively high concentrations of radioactivity* and have been generally recognized . . . as being unsuitable for dumping, for example, the 'first cycle wastes' from nuclear reprocessing, irradiated fuel and irradiated fuel cladding." IAEA Definition and Recommendations, *supra* note 17, Annex at ¶ 2.3.1. At the third consultative meeting, at which the revised IAEA Defintion and Recommendations were transmitted to the London Convention parties, the IAEA representative stated his agency's conclusion that only release rates were important in the control of dumping and that release rate limits should be the basis of control; he suggested consideration of amending Annex I(6) to this end. *See* IMCO, Report of the Third Consultative Meeting of Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, IMCO Doc. LDC III/12, Annex 8 at ¶ 6 (1978). The representative of the U.K. proposed that the IAEA be requested to explore further a proper scientific basis for the control of radioactive waste dumping. *Id.* Annex 9 at ¶ 5(6)-(7). The representative of the U.S. stated that his government felt "strongly" about maintaining the prohibition on high level waste disposal and that it had "strong reservations" to using release rate limits without reliable containment systems that would release waste in a quantifiable manner and that were demonstrated both in the laboratory and *in situ. Id.* at ¶ 6. The United States delegation had gone to the third consultative meeting of the London Convention parties prepared to oppose any attempt to amend Annex I(6) to permit the IAEA to base its definition of high level waste on release rates, specifically any language to the effect that, "There are no high-level radioactive wastes that are intrinsically unsuitable for dumping at sea but quantities dumped should be strictly controlled on the basis of release rate limits." *See* United States Environmental Protection Agency, London Ocean Dumping Convention Third Consultative Meeting, Agenda Item 6 (Oct. 9-13, 1978) (briefing paper). The IAEA representative also indicated at the meeting that adoption of release rate limits would require the establishment of a system of notification and *prior* consultation in addition to other administrative measures. *See* IMCO Doc. LDC III/12, Annex 8 at ¶ 6.

The belief that high level waste resulting from direct contact from spent nuclear fuel must be treated differently than other wastes arises because of its much greater overall radioactivity and the presence of large amounts of long-lived nuclides. If there were a failure of con-

The IAEA is not authorized to determine the scope of "dumping" subject to the London Convention. If the IAEA proceeded to define high level waste in terms of release from containment, parties to the Convention could claim that it had not provided a definition of the prohibited substance, as required,[378] but had in effect decided that otherwise prohibited wastes, if disposed in a certain manner, were not dumped at all. But if the parties wished to alter the scope of the term "dumping" or otherwise make special arrangements for seafloor emplacement they could do so explicitly. If, however, the parties wished to take this step without initiating the action themselves, they could acquiesce in definitional action by the IAEA. In the latter case, there would be an action by an international organization that could carry more weight outside the circle of countries currently active in regulating sea dumping of radioactive wastes.

Similar issues are presented by potential seabed emplacement of high level waste. Seabed emplacement was conceived in order to provide greater isolation and containment of waste nuclides. The release rate concept underlying the work of the IAEA could also provide a basis for the acceptance of seabed emplacement of high level waste.[379] Seabed emplacement creates additional problems of definition, however.[380] The London Convention defines dumping as "any deliberate disposal at sea of wastes or other matter from vessels, [etc.] at sea."[381] Ultimate disposal, it appears, must be "at sea"; this interpretation is confirmed by the recurrence of the phrase in describing the location of the disposing agent.[382] The background and certain characteristics of seabed emplacement argue against considering it a method of disposal "at sea."[383] Initial

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tainment, such levels of activity at a site could pose an enhanced danger to man because the escape of long-lived radionuclides would be possible. It is generally recongized that more scientific research on the behavior of these substances in the marine environment is required. *See* NEA Tokyo Seminar, *supra* note 41, at 395 (remarks of Mr. Pentreath); de Bettencourt, *supra* note 269, at 48.

378. *Cf.* London Convention, *supra* note 5, Annex I.

379. *See* Templeton, *Radiological Aspects of Seabed Dumping in the Deep Oceans* in NEA Tokyo Seminar, *supra* note 41, at 31-32.

380. For an extensive review of these definitional problems, see D. DEESE, NUCLEAR POWER AND RADIOACTIVE WASTE: A SUB-SEABED DISPOSAL OPTION? 81-87 (1978).

381. *See* London Convention, *supra* note 5, art. III(1)(a)(i).

382. *See* D. DEESE, *supra* note 373, at 83.

383. Seabed emplacement was developed by the United States as a variety of geological emplacement. *See* SDP PLAN, *supra* note 135, at 7. Some federal officials have stressed that seabed emplacement is not dumping but geological isolation. "The seabed concept is . . .

work on this technique was ostensibly aimed at achieving complete or nearly complete isolation of the wastes from the marine environment,[384] but it now appears that the objective is "satisfactory containment"[385] accompanied by a recognition that certain waste nuclides might escape.[386] The nature of transportation to the disposal site (i.e., by and from ships) does not appear legally significant in this connection, since nothing currently prohibits maritime transportation of high level waste to a repository or elsewhere.

There has been little development of this legal issue on the international level. A draft of the IAEA Definition and Recommendations circulated shortly after the London Convention was signed stated that seabed emplacement should be considered a form of geological disposal and not dumping within the scope of the IAEA regulations.[387] The statement was deleted after the United States objected to its inclusion in a section entitled "Sources of Radioactivity in the Sea"[388] since, it was claimed, it would not be such a source.[389] IAEA's radiological consultants viewed seabed emplacement as a technique of waste containment that should be explored as a method to limit releases.[390]

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quite unlike sea dumping and should be thought of as a variant of isolation of radioactive waste within stable geological formations on land, the difference being that the coordinates are at sea." *Oversight Hearings on Radiological Contamination of the Oceans: Before House Committee on Energy and the Environment*, 94th Cong., 1st & 2d Sess. 546, 555 (1976 & 1977) (statement of James L. Liverman) [hereinafter cited as 1976 *Oversight Hearings*]. *See also* 1980 *Hearings, supra* note 1, at 3-4 (statement of Sheldon Meyers). On the other hand, it could occur at ocean coordinates and in sediments formed by oceanic processes and permeated by seawater. *See generally* Corliss & Hollister, *Cenozoic sedimentation in the central North Pacific*, 282 NATURE 707 (1979).

384. "The radioactive material itself does not, therefore [*sic*] come into contact with the ocean and become dispersed." 1976 *Oversight Hearings, supra* note 376, at 554 (statement of James L. Liverman).

385. *See* 1980 *Hearings, supra* note 1, at 5 (statement of Sheldon Meyers).

386. *See* note 148 *supra*.

387. "Certain methods of radioactive waste disposal, although not feasible at this time, may eventually be developed technically to the point of proposing the long-term isolation of wastes by emplacement beneath the seabed. Such methods should be evaluated as variations of deep geological burial on land and are excluded from the scope of this document because they will not contribute to the radioactivity of the sea." IAEA Doc. GOV/1622 (Sept. 3, 1977).

388. Now Sec. 2.2. of the Annex to the IAEA Definition and Recommendations, *supra* note 17.

389. *See* Airgram No. A9894 from U.S. Department of State to IAEA (Nov. 30, 1973). Professor Deese reports that the proposed exclusion of seabed emplacement from the IAEA Definition and Recommendations was dropped due to the difficulty of defining emplacement in the seabed. *See* 1976 *Oversight Hearings, supra* note 376, at 963, n.1.

390. *See* IAEA Radiological Consultants, *supra* note 319, at 28.

Aside from the esoteric issue of whether seabed emplacement would be dumping within the London Convention, the issues associated with it are equivalent to those raised by seafloor emplacement. These are the reasonableness of the activity as a use of the high seas and its effect on the seabed beyond national jurisdiction. Any ocean disposal of high wastes would necessarily involve a risk of pollution to the seas—indeed to the entire ocean—that could ultimately interfere with legitimate uses of the high seas and degrade marine resources within national jurisdiction. Several scientific experts have claimed that high level waste disposal in the deep ocean, even without advanced containment, would not significantly pollute the seas.[391] The current consensus of scientific opinion would appear to be, however, that such disposal would be unacceptable unless effective, long-term containment could be provided.[392] Acceptable emplacement would also entail further development of international understanding and regulation of other aspects of the operation—including improved oceanographic mod-

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Various United States government agencies have reviewed the legality of seabed emplacement under the London Convention. Potential seabed emplacement, and aspects of low level waste dumping, have been aired before Congressional committees three times; once in 1976, see 1976 *Oversight Hearings, supra* note 515; once again in 1978, see *Hearings Before the House Subcommittee on Oceanography and on Fisheries and Wildlife Conservation and the Environment, Committee on Merchant Marine and Fisheries*, 95th Cong., 1st & 2nd Sess. (1978); and most recently before the House Oceanography Subcommittee on Nov. 20, 1980, see 1980 *Hearings, supra* note 1. Useful statements on institutional questions associated with seabed emplacement and on factual and institutional aspects of sea dumping may be found in all these records.

The Department of State has assimilated the question of the coverage of the Convention to the issue of whether seabed emplacement would present "a threat of pollution to the marine environment." *See* 1976 *Oversight Hearings, supra* note 376, at 798-99. The EPA, which would issue permits for such activities if they constituted ocean dumping subject to the MPRSA, has recognized the ambiguity of the Convention. However, EPA has concluded that seabed emplacement would be prohibited under the MPRSA. *See* Memorandum from James A. Rogers, Asst. General Counsel, to Dr. William D. Rowe, Deputy Asst. Administrator, *reprinted in* 1976 *Oversight Hearings, supra* note 376, at 818-819. DOE, which currently is responsible for developing the program, does not currently take a position on this issue. *See* 1980 *Hearings, supra* note 1, at 7 (statement of Sheldon Meyers). It is fair to say, however, that approximately the same ambiguity exists in the MPRSA as in the London Convention on the question of whether seabed emplacement would be "dumping." The Act defines "dumping" as "a disposition of material," 33 U.S.C. § 1402(8) (1976) and prohibits dumping "into ocean waters," 33 U.S.C. § 1411(a) (1976). Statutes enacted by other nations on this subject contain similar ambiguities; some of these are reviewed in Deese, *Seabed Emplacement and Political Reality*, 20 OCEANUS 47, 55-58 (1977).

391. *See* 1980 *Hearings, supra* note 1, at 8-10 (statement of James P. Walsh).

392. *See* NEA STUDY, *supra* note 8, at 51, 55-56.

elling,[393] assessment of site-specific conditions, and appreciation of the behavior of long-lived radionuclides in the marine environment.[394] The disposal sites should be chosen to optimize the success of initial emplacement, subsequent geological and biological isolation, monitoring, and perhaps eventual retrieval.

Although subject to legally distinguishable terms, emplacement in the deep sea, disposal on islands and the use of continental shelf geological formations all involve similar considerations concerning potential pollution of the marine environment. While deep ocean emplacement would probably be considered a high seas activity subject to the "reasonableness" requirement, island or continental shelf disposal would in the first instance be subject to some form of national jurisdiction—tempered by the requirement that transboundary pollution be avoided. Because of the potential global radiological effect of releases of significant quantities of the long-lived radionuclides from high level waste repositories, however, there appears to be little real distinction between these situations. In both cases—high seas or other jurisdictional zone—the question is whether the activity poses an unacceptable risk of pollution to the global marine environment. In this sense even land repositories would be subject to a similar requirement,[395] although less directly. It appears that such a question could not be resolved on a national basis, but would involve international determination of acceptable waste disposal policies in light of the range of ocean disposal activities expected, current and future uses of the oceans for other purposes, and related developments including other sources of radioactivity in the sea and the effect of other polluting activities.

Seafloor and seabed emplacement would also involve use of the deep seabed beyond national jurisdiction (the Area)[396] for disposal. Use of the Area raises questions concerning potential conflict with the developing concept of the "common heritage of mankind."[397] The chief issue in this respect would appear to be the nature and extent of the collective interest in the Area and in activities conducted in it. The Draft LOS Convention provides: "No State shall claim or exercise soverignty or sovereign rights over any part of the

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393. *See* NEA Tokyo Seminar *supra* note 41, at 395 (comments of Mr. Webb).

394. *See id.* (comments of Mr. Pentreath).

395. *See* NEA STUDY, *supra* note 8, at 61.

396. The seabed, ocean floor, and subsoil beyond the limits of national jurisdiction are termed "the Area" in the Draft LOS Convention, *supra* note 26, art. 1(1).

397. *Id.* art. 136. *See also* text at notes 259-62 *supra*.

Area or its resources, nor shall any State appropriate any part thereof."[398] It is not clear whether or not the establishment of a high level waste repository on the seafloor or in the seabed would constitute such an exercise of sovereignty or appropriation of part of the Area. Although Part XI of the Draft LOS Convention was formulated primarily to regulate the new technology of deep sea mining for manganese nodules,[399] the text is not restricted to such resources but speaks generally of the Area and its resources.[400] A broad list of resources is given which includes non-manganese nodule resources but is generally confined to minerals or mineral-bearing substances.[401] "Activities in the area," which are subject to regulation under several provisions,[402] are restrictively defined to include only resource-related activities.[403] It does not appear possible at this time to determine whether deep ocean emplacement would be subject to this regime. Deep ocean repositories could be located away from potential mineral recovery areas.[404] After seabed emplacement, it is even possible that mineral resources on the seafloor or in shallow sediments could be recovered normally. Concerning the capacity of the deep seabed to serve as a repository for high level wastes, there would appear to be no realistic limit imposed by the size or characteristics of the area required.[405] Limitations on use arise only because of extrinsic determinations concerning the desirable extent of use of a single site[406] or of general reliance on the oceans as a disposal location for high level waste. That is to say, the capacity of the deep seabed to serve as a repository for high level waste is not intrinsically a scarce resource.

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398. *Id.* art. 137(1).

399. *See, e.g.*, Deep Seabed Hard Mineral Resources Act, Pub. L. No. 96-283 § 2(a)(7)-(8), 94 Stat. 553 (1980)(supported U.N. General Assembly Principles Resolution in expectation of comprehensive law of the sea treaty which would provide a new order for the oceans, including specifically exploitation of hard mineral resources of the deep seabed).

400. *See* Draft LOS Convention, *supra* note 26, arts. 136, 137(1).

401. *Id.* art. 133.

402. *See, e.g., id.* art. 143(3) (coastal state right to take action against activities in the Area threatening their environmental interests); *id.* art. 145 (measures to ensure effective protection of the marine environment from activities in the Area); *id.* art. 147 (conduct of activities in the Area and related installations).

403. *Id.* art. 1(3) ("Activities of the Area" means all activities of exploration for, and exploitation of, the resources of the area.).

404. *See* text at notes 262-63 *supra*.

405. For estimates of the seabed area that would be needed, see DOE GENERIC EIS, *supra* note 20 at 6.68.

406. *See* Nielsen, *supra* note 359, at 552.

A State operating a deep ocean repository might wish to prevent unauthorized parties from interfering with it.[407] There would be little incentive, however, for another State or a non-state actor to deliberately intrude. High level waste in a deep ocean repository would be an unappealing target for the diversion or deliberate dispersal of nuclear materials, both because of the characteristics of the waste[408] and the location of the repository.[409] National surveillance could probably be limited, therefore, to warning other states of the existence of the repository and deterring irrational actions, presumably by non-state groups.[410]

III. OCEAN DISPOSAL OF RADIOACTIVE WASTES AND INTERNATIONAL ORGANIZATION

The nature of the sea dumping conducted since 1946 has made it necessary for States to cooperate in limited and universal membership organizations to address technical and administrative issues. To regulate the dumping of low level waste, States have adopted controls on both a global (London Convention) and regional (*e.g.*, Oslo Convention) level and on an inclusive (IAEA) and exclusive (NEA) basis.[411] For the many parties to the London Convention,[412]

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407. *See generally* DOE GENERIC EIS, *supra* note 20 at 3.22-3.24. It may be desirable to design operations in such a way that the repository would be of minor interest to any future civilization that might be tempted to disturb it and such that the consequences of disturbance would be minimal. *See generally* Rochlin, *supra* note 123, at 26-28. Seabed emplacement would appear to meet these criteria, especially if waste canisters were spread out over a wide area. *Id.* at 27-28.

408. Neither spent fuel nor high level wastes from reprocessing are good candidates for diversion. Spent fuel is low in fissile content and difficult to handle because of its high radioactivity. *See* DOE GENERIC EIS, *supra* note 20, at 3.23. More attractive opportunities for diversion exist, especially if reprocessing and recycling of fuel to advanced reactors occurs on a broad scale. *See generally* G. ROCHLIN, *supra* note 19, at 213-56. High level wastes from reprocessing have had nearly all their fissile material removed, so they would be unlikely candidates for diversion except to make a threat of "malevolent dispersal." *Id.* at 215. The isolated location of a high level waste repository would make these wastes difficult to recover intact for purposes of dispersal elsewhere; any dispersal at the repository site would not be catastrophic provided the site is sufficiently isolated, as it would be diluted by the ocean. *See generally* DOE GENERIC EIS, *supra* note 20, at 3.23.

409. *See id.* at 6.81.

410. *See id.* For a description of various measures subsumed under the concept of surveillance of a high level waste repository, see Strohl, *Legal Administrative and Financial Aspects of Long Term Management of Radioactive Wastes*, 21 NUCLEAR L. BULL. 77 (1978).

411. For a discussion of global and regional levels and inclusive and exclusive "modes" of organization, see G. ROCHLIN, *supra* note 19, at 192-96.

412. Forty-seven states were parties to the London Convention as of Nov. 20, 1980. *See* 1980 *Hearings*, *supra* note 1, at 1 (statement of Leslie H. Brown).

special permits must be issued for waste dumping and notifications of such operations communicated to the other parties through IMCO.[413] The recommendations of the IAEA, formulated on the basis of international expert advice, must be observed in issuing such permits.[414] For participants in NEA operations or the OECD mechanism, operational control is more rigorous and includes joint site designation, prior notification, and expert advisement. Through such measures, an international regime has been provided for the effective regulation of low level waste dumping.[415] As operations grow in magnitude, existing controls will have to be developed and refined and further disagreements over regulation can be expected. Some of these could be settled through formal international procedures such as the dispute resolution protocol to the London Convention adopted in 1978[416] but many, especially scientific and administrative issues addressed through the IAEA and NEA, will probably be resolved on the technical level within international organizations.

High level waste disposal involves more serious concerns, however, and new procedures will be required to ensure that any such activities are subject to adequate international regulation. Because of the current prohibition on disposal at sea of high level waste under the London Convention,[417] some action would be necessary within the Convention framework before deep ocean emplacement could be undertaken. Although action of a definitional nature could be taken by the IAEA in appropriate political circumstances, amendment to the annexes of the Convention, including adoption of a special set of regulations for emplacement, would most likely be required.[418] Both the high seas and the seabed beyond national jurisdiction are subject to certain collective interests of the world community.[419] These make it unlikely that ocean disposal of high

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413. *See* text at notes 176-77 *supra*.

414. *See* text at notes 175 *supra*.

415. *See* NEA STUDY, *supra* note 8, at 49-50.

416. London Convention, *supra* note 5, art. XI (amended) & app. A. Under this protocol disputes may be submitted to the International Court of Justice, upon consent of the parties, or to arbitration, upon request of one party to the dispute. *Id.* art. XI. The rules for arbitration are given in Appendix A.

417. *Id.* at art. IV(1)(a) & Annex 1(a).

418. *See* text at note 363 *supra*.

419. This is true under both the "reasonable use" doctrine and the "common heritage of mankind" principles discussed earlier, see text at notes 158 & 255-62 *supra*. *See generally* Bilder, *supra* note 194, at 457-58, 462-67.

level waste could be politically possible if practiced unilaterally.[420]

The functions of international organization with respect to control of the nuclear fuel cycle can be classified as informational, managerial, and operational. Within these functions it is possible to implement a common framework for policymaking, adopt a common policy, promulgate a single policy, or conduct joint operations. The present organization of sea dumping of low level waste is primarily informational in function and intended to provide a common framework for national decision-making. Elements of international management with common policy or even joint operations can be discerned, for example, in the dispute settlement protocol to the London Convention,[421] the powers of regional commissions,[422] NEA operations and the OECD mechanism. Commentators have suggested that ocean disposal of high level waste would require, politically, at least some form of international managerial authority empowered to formulate common policies.[423] States have indicated a degree of willingness to enter binding organizational commitments of this nature. For example, under the Euratom Treaty,[424] the nations of the European Economic Community have agreed to an extensive system of international management of members' nuclear waste disposal practices.[425]

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420. *See* G. ROCHLIN, *supra* note 19, at 298.

421. London Convention, *supra* note 5, art. XI & app. A.

422. The Commission established under the Oslo Convention may comment on dumping operations reported by parties. *See* Oslo Convention, *supra* note 73, art. 17. Under the Helsinki Convention, a Baltic Marine Environment Protection Commission will be established with general oversight responsibilities. *See* Helsinki Convention, *supra* note 177, arts. 12 & 13.

423. *See* G. ROCHLIN, *supra* note 19, at 303.

424. Treaty Establishing the European Atomic Energy Community, *done* March 25, 1957, 298 U.N.T.S. 167 (1958) (entered into force Jan. 1, 1958) [hereinafter cited as EURATOM Treaty].

425. *Id.* arts. 30-32. The Commission of the European Communities is authorized to establish radiation protection norms. It has *inter alia* adopted the dose limitations and other recommendations of the ICRP. Members are required to control radioactivity within these norms and to establish facilities to maintain the prescribed limits. They must inform the Commission of likely resulting radiation levels and submit general data on any plans for waste disposal. The Commission may examine national control facilities and review plans to determine if transfrontier contamination would result, with the aid of expert consultants. The Commission has six months to issue its opinion on proposed disposal and may also issue recommendations to members on radioactivity levels. The agent state, other members, or the Commission may appeal actions to the European Court of Justice. In extreme cases the Commission may request that a state take necessary measures to prevent levels of radioactivity being exceeded or otherwise ensure compliance with common standards. EURATOM Treaty, *supra* note 417, arts. 33-38.

International radioactive waste management, while workable on a regional scale, presents serious obstacles when considered on a world-wide basis. But with the exception of operational aspects of actual disposal, the nature of the high level waste problem is not amenable to regional solution.[426] The potential consequences of inadequately conceived disposal methods and the political realities of use of the high seas and seabed beyond national jurisdiction appear to make at least a universal common policy indispensable. Some formal international negotiation, probably on an inclusive and global basis, will probably be necessary before ocean disposal of high level waste could occur.[427] A variety of measures short of international management, such as monitoring and exchange of information, advance notification and consultation, and dispute settlement,[428] have already occurred for current ocean disposal practices, although sometimes on a limited basis. In view of the history of cooperation in this field, the opinions of scientific experts, and the growing tendency to use managerial methods to control nuclear development[429] and regulate sources of marine pollution,[430] it would be difficult for any State or group of States to proceed with ocean disposal of high level radioactive waste in the absence of an international regulatory regime.

IV. OCEAN DISPOSAL OF RADIOACTIVE WASTES AND INTERNATIONAL EQUITY

International equity concerns inevitably arise in attempting to formulate legal principles governing the conduct of States with respect to the management of natural resources and protection of the

426. *See* Rochlin, *supra* note 19, at 304.

427. *Id.* at 298.

428. These are given as examples of measures short of actual international management of a shared or common heritage resource in W. Riphagen, *The international concern for the environment as expressed in the concept of "common heritage of mankind" and of "shared natural resources"* 13 (1979) (unpublished manuscript, copy on file with the author).

429. A number of bilateral and multilateral agreements have been concluded providing for international management of siting, operation, or contingencies involving nuclear facilities in certain areas, especially in border regions. These include the Nordic Mutual Energy Assistance Agreement in Connection with Radiation Accidents (1963) and the Franco-Belgian Agreement on Radiation Protection at the Centrale Nucleaire des Ardennes (1966). *See generally* Note, *International Co-operation in the Field of Radioactive Transfrontier Pollution,* 14 NUCLEAR L. BULL. 55, 62-64 (1974).

430. *See* text at notes 194-201, 214 *supra.*

environment.[431] States sharing resources are obliged to engage in a cooperative effort to achieve an equitable utilization of such resources.[432] States, despite their permanent sovereignty to develop their own resources in line with national environmental policies, have an obligation to avoid pollution of the global commons and other transfrontier areas.[433] Pollution, specifically marine pollution, is defined with reference to the equitable interests of other States in use of the natural resources available to them on a collective or individual basis.[434] The doctrine of reasonable use of the high seas protects the equitable interests of other States in uses of the high seas, especially the traditional maritime freedoms. In addition, the "common heritage" regimes developed through international diplomacy, including those for the seabed beyond national jurisdiction[435] and for the moon and other celestial bodies,[436] are intended to insure equitable international sharing of the resources of such domains through special arrangements.[437]

Ocean disposal of high level radioactive waste and increased coastal discharges due to widespread reprocessing of spent fuel, if conducted by one or more nations on a limited basis, would result in the creation of a certain level of risk to the benefits derived from marine resources. Pollution arising in this fashion could affect marine areas subject to some form of national jurisdiction, as well as those beyond national jurisdiction. Since the benefits of nuclear power currently accrue primarily to several advanced industrial States,[438] these risks and use would largely redound to the benefit

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431. For a general exposition of environmental rights and responsibilities in light of international equity considerations, see W. Riphagen, *supra* note 421. For an analysis of the intersection of such considerations with specific patterns of allocation of natural resources, see Bilder, *supra* note 194. For general reflections on the relation of natural resources policy to internatonal equity, see O. SCHACHTER, *supra* note 213, at 35-83.

432. *See* text at notes 232-36 *supra*.

433. *See* text at notes 218-22 *supra*.

434. For a discussion of these bases of entitlement of states to natural resources, see Bilder, *supra* note 194, at 453-62.

435. *See* text at notes 259-62, 389-96 *supra*.

436. *See* Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, art. II(1), Annex to U.N. GAOR 34/68 (Dec. 14, 1979) [hereinafter cited as Moon Treaty]. 18 INT'L LEGAL MATERIALS 1434 (1979).

437. *See e.g.* Moon Treaty, *supra* note 429, art. II(5): "States parties to this agreement hereby undertake to establish an international regime, including appropriate procedures, to govern the exploitation of the natural resources of the moon as such exploitation is about to become feasible. . . ."

438. Currently forty-five countries are operating or constructing nuclear power plants, totaling 395. Of these 166 are in the United States, 39 in the United Kingdom, 27 in the

of only a few States.[439] This asymmetry in benefits could be reduced, but probably not eliminated, by unilateral measures by States which have developed reprocessing and waste disposal functions. For example, the developed nations could export equipment, transfer technical information, or provide financing to less developed States to help give them access to nuclear technology. Multilateral solutions could also be found, such as the establishment of an international authority to develop and manage fuel cycle technology or an international corporation to provide fuel cycle services.[440] It is difficult to say at present what form such institutions should take, but experience at UNCLOS III and at other international conferences considering basic issues of international equity suggests that most ocean disposal options would not be politically viable unless steps were taken within the world community to achieve a consensus on the organizational prerequisites of such activities.[441]

Any international management of high level waste disposal on a bilateral or multilateral basis would have to be related to the resolution of other outstanding issues in the organization of the nuclear fuel cycle. Assuming that reprocessing of spent nuclear fuel occurs on a widespread basis, international arrangements will have to be made to deal with the security and environmental issues associated with the full range of back end operations.[442] The chief issue in this connection has been how to prevent the large amounts of plutonium generated, transported, and stockpiled as a result of reprocessing from being used in the construction of nuclear weap-

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Soviet Union, 27 in France, 24 in Japan, 19 in the Federal Republic of Germany, and 17 in Canada. *See* J. DUDERSTADT & C. KIKUCHI, NUCLEAR POWER: TECHNOLOGY ON TRIAL at 51, 124-25 (1979).

439. Such inequity would be further enhanced if, as suggested, nations provide reprocessing and disposal services on a commercial basis. *See, e.g.*, ROYAL COMMISSION REPORT, *supra* note 37, at 159-62.

440. A lengthy and systematic analysis of the potential institutional alternatives for various back end operations is given in G. ROCHLIN, *supra* note 19, at 189-306.

441. The states of the Southern hemisphere have generally sought, in North-South negotiations, to interpose institutional solutions in inequitable situations that have arisen as the result of received economic and political factors. These have included calls for redefining the roles of existing institutions like the World Bank and the International Monetary Fund, changing the representation and voting procedures in such bodies, and creating new organizations to remedy existing imbalances (*e.g.*, the International Commodities Fund) or to preclude new inequities from arising (*e.g.*, the Seabed Authority). *See generally* BRANDT ET AL., NORTH-SOUTH: A PROGRAMME FOR SURVIVAL (Report of the Independent Comm'n on Int'l Development Issues) (1980).

442. *See* G. ROCHLIN, *supra* note 19, at 189-306.

ons by states or non-state groups which do not now possess them.[443]

Assuming that satisfactory international arrangements can be created for spent fuel reprocessing and resupply, then accompanying high level waste management institutions should be designed with several goals in mind.[444] These goals include economic efficiency, the reduction of environmental hazards (especially those associated with maritime transportation of high level waste) and the equitable provision of disposal services to less developed countries. Various institutional forms and functional combinations have been proposed[445] to provide back end services on an international basis. "Fuel cycle centers" could provide services,[446] most probably on a regional basis,[447] and would probably involve colocation of various facilities in order to reduce the safety and security risks associated with transportation and widely scattered independent activities.[448] Fuel cycle centers could be operated on a national or international basis and sensitive operations could be conducted either within a facility or enclave inside national home territory or in remote areas. Designing an international organization to administer back end operations would involve resolving many delicate questions about the powers and structure of the organization.[449]

Remote locations have been suggested for various back end operations, including spent fuel storage,[450] reprocessing and associated

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443. For a synoptic analysis of the political issues, see *id.* at 103-86. U.S. policy is described in Power, *The Carter Anti-Plutonium Policy,* 7 ENERGY POL'Y at 215-231 (1979); Walsh, *Fuel Reprocessing Still the Focus of U.S. Non-Proliferation Policy,* 201 SCI. 692-97 (1978). U.S. reliance on technical solutions is criticized as disingenuous in Wohstetter, *Spreading the Bomb Without Quite Breaking the Rules,* 25 FOREIGN POL'Y 88-179 (1976); it is criticized as ingenuous in Rose & Lester, *Nuclear Power, Nuclear Weapons and International Stability,* 238 SCI. AM. 45-57 (Apr., 1978). A statement of the position advocated by French officials and some scholars, along with intense criticism of the American position, is given in B. GOLDSCHMIDT, LE COMPLEXE ATOMIQUE: HISTORIE PUBLIQUE DE L'ÉNERGIE NUCLÉAIRE 414-44 (1980).

444. *See generally* G. ROCHLIN, *supra* note 19, at 257-306.

445. *Id.* at 189-306.

446. *See, e.g.,* 9 INFCE, *supra* note 96 at 200-02 (Fuel Cycle Centre proposal).

447. *See generally* IAEA Doc. RFCC/2 (July, 1976) (Regional Nuclear Fuel Cycle Centres) (1977). Analyses of needs and prospects for integrated spent fuel disposition in several regions may be found in NUCLEAR NONPROLIFERATION: THE SPENT FUEL PROBLEM (F. Williams & D. Deese eds. 1979).

448. *See* G. ROCHLIN, *supra* note 19, at 259-62.

449. *See id.* at 266-93.

450. United States officials have indicated that they are considering using Palmyra Island in the Pacific as a storage site for spent fuel returned from Japan. *See Plan for Storing Nuclear Wastes on Pacific Atoll Strongly Protested,* Wash. Post, Aug. 23, 1979, § A, at 4,

activities, and high level waste disposal.[451] Such locations have appeared attractive in order to defuse domestic opposition to back end operations, to avoid national resistance to accept spent fuel or wastes from abroad, and to encourage international solutions to the organization of the back end of the nuclear fuel cycle.[452] Location of fuel cycle services in remote areas could lessen the reluctance of nuclear suppliers to permit international control of such operations.[453] A number of operations could be concentrated at a single remote site to minimize the hazards of transportation losses and the dangers of diversion or theft[454] while realizing the economic advantage of colocation and large scale operation.[455] Remote sites could be chosen for convenience of regional transportation and proximity to disposal locations. While the detailed analysis necessary to project the characteristics of such sites is not now available, it would appear that any such strategy would place substantial reliance on the oceans for transportation, physical security, and possibly waste disposal.

Exposing the oceans to the risks of maritime accidents involving highly radioactive cargoes, high-level waste disposal in ocean locations, or greatly increased levels of reprocessing discharges requires generally acceptable international organization of the fuel cycle and consequent waste disposal. Such organization is required both as a matter of environmental policy and as a result of equity concerns. The relationship of waste disposal to other controversial issues concerning the back end of the nuclear fuel cycle means that nations proposing systematic ocean disposal of fuel cycle wastes will likely have to resolve in a generally accepted manner the outstanding equity issues concerning the sharing of the benefits of nuclear technology for peaceful purposes.

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col. 1; *Tiny Pacific Island of Palmyra Targeted as Nuclear Dump, id.*, Aug. 18, 1979, § A, at 1, col. 1. The U.S. State Department has recently (July 18, 1980) concluded an agreement with the Japanese government to study interim storage of spent fuel on a Pacific Island: in November, 1980 a 2-year work plan was agreed upon. 1980 *Hearings, supra* note 1, at 6-7 (testimony of Leslie H. Brown).

451. *See* G. ROCHLIN, *supra* note 19, at 208.

452. *Id.* at 302-05, 329. *See generally* 9 INFCE, *supra* note 96, at 235.

453. *See generally* G. ROCHLIN, *supra* note 19, at 277-78.

454. *See generally id.* at 247-56, 292.

455. For a general discussion of the economics of reprocessing, see *id.* at 284-92.